AFRICA

WATER ATLAS

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Bruce Pengra/UNEP

Foreword

The Millennium Declaration was our boldest political commitment as heads of state and governments to provide focused leadership and champion good governance to eliminate illiteracy, poverty, disease and environmental degradation by 2015. The Declaration was a pro-poor statement that was subsequently encapsulated into eight Millennium Development Goals (MDGs), setting specific targets negotiated at high-level meetings.

It has been ten years since the Millennium Declaration and as this Atlas makes evident, significant progress has been made in the water sector in Africa, but a lot more remains to be done. It also shows that although there has been important cross-border and sub-regional dialogue and cooperation, a dearth of scientific data and information impedes efforts to manage water issues better. Therefore, this Africa Water Atlas has been wisely and skilfully packaged to trigger continuous debate and dialogue to define an agenda for discussions and strategy planning among ordinary citizens and between water experts within countries and across national borders.

My own country, Liberia, is not dissimilar to many African countries that continue to face challenges in meeting the MDG targets on water and sanitation. At the 64th Session of the UN General Assembly, the Secretary General Ban Ki-Moon noted that "It is clear that improvements in the lives of the poor have been unacceptably slow, and some hard-won gains are being eroded by the climate, food and economic crises." Whereas, on average, the world will meet the MDG water targets by 2015, Africa will not, and the effects of climate change exacerbate the situation of water scarcity.

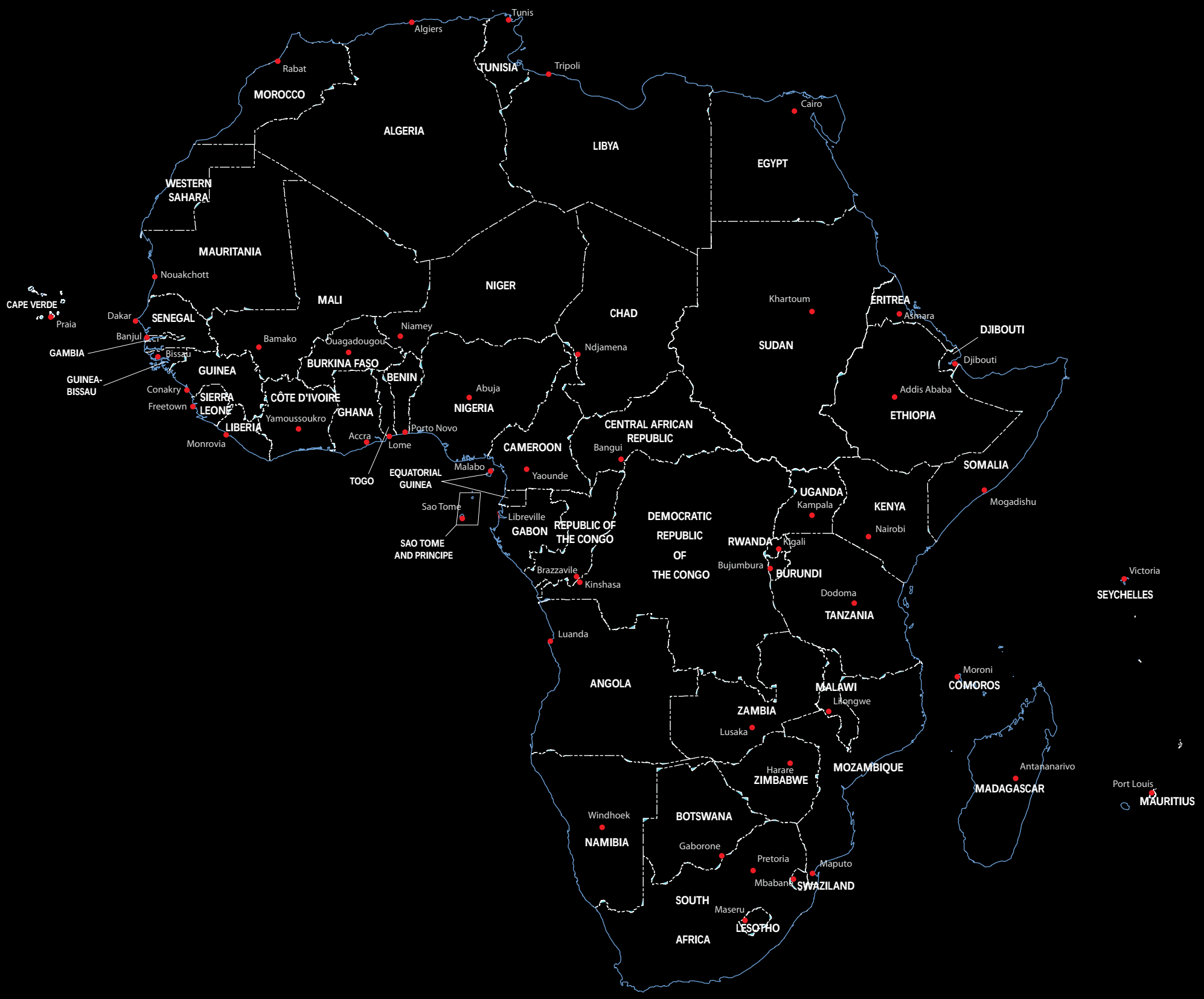
Only 26 countries in Africa are expected to halve the proportion of their citizens without access to improved water by the targeted deadline. It is reliably estimated that in view of increasing population growth and the spiralling cycle of poverty, new models must be developed if the MDG targets on water are to be met by 2015. These estimates show that continental coverage needs to increase from 64 per cent in 2006 to 78 per cent by that date.

The sanitation situation is yet another challenge that needs our special focus as political leaders: only nine countries in Africa will meet the MDG sanitation target. It is heartbreaking and unacceptable that only half of Africa's population use improved sanitation facilities and that one in four has no such recourse. Because of such unsanitary conditions, globally more children under the age of five die of diarrhoea than of AIDS, measles and malaria combined. Investing in safe toilet facilities, clean drinking water supplies and raising awareness of hygiene practices could protect vulnerable populations from these deaths.

The commitment of some African nations to allocating 0.5 per cent of their GDP to sanitation under the e-Thekwini Declaration is an encouraging step forward. In Liberia, just 17 per cent of the population has access to proper sanitation, but increased budgetary allocation by governments to the water and sanitation sector last year alone has reduced child mortality. To meet the MDG sanitation target of halving the proportion of people without sustainable access to basic sanitation, coverage in Africa needs to increase from 38 per cent in 2006 to 67 per cent in 2015.

This Africa Water Atlas vividly illustrates the importance of Africa's water resources in supplying millions of people with life-giving water and in supporting activities that are crucial to our ecosystems and economies. I encourage every leader and policy maker in Africa to open these pages, and not only marvel at the images, but take stock of important messages it has to offer that will help Africa move faster towards the MDG water targets and secure a better future for our children and generations to come.

H.E. President Ellen Johnson Sirleaf
Republic of Liberia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Preface

Since Africa's water resources are so vital to basic livelihoods and economic growth on the continent, an improved understanding of its availability, distribution and limitations is crucial for its better management. Sustainable small-scale and large-scale agriculture, commercial and artisanal fisheries, livestock keeping and range management, industrial growth, hydropower development and biodiversity all depend on water and the better management of this resource.

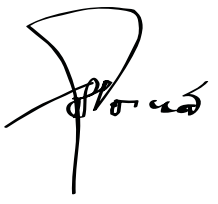
One of the most striking lessons this Africa Water Atlas brings to light is that water resources are plentiful in many African countries. However, one of the untold development ironies and tragedies facing the continent is that too many people don't have access to safe drinking water, and many more lack adequate sanitation facilities. The Atlas reveals the challenges of moving towards the water-provision targets, but also highlights solutions to better manage water and sanitation services that could help achieve them.

Reasons for this disparity in distribution are geographical—topographic elevations and proximity to the Equator cause seasonal variations, for example. These features create climatic variability that is sometimes exacerbated by cycles of floods and drought events. Notwithstanding, there are significant political and economic factors that influence availability and access to water resources. The situation of water scarcity is not made any better by the influx of people to burgeoning cities and slums as they escape from rural environments that are increasingly becoming economically unsustainable. Water stress due to such variability in access has damaged water resources, prevented their development or sparked conflicts between neighbours over shared water.

This Africa Water Atlas provides a reference for our political leaders to work together to develop and implement policies and laws that will protect Africa's water resources, especially by applying Integrated Water Resources Management (IWRM) to better manage water basins and sub-basins. IWRM is a useful strategy in dealing with waters that flow over political boundaries and in managing watersheds and drainage basins shared by two or more countries.

A special feature section of the Atlas gives optimism for addressing water concerns: it shows that although the presence of "hotspots" where rain-fed agriculture is constrained and food security is tenuous is a formidable challenge, Africa has many "hopespots" where long-practiced water-harvesting strategies that have been used as "coping mechanisms" can be expanded and new practices adopted, especially in light of the changing climate. Africa needs to be resilient to develop and spread these promising tools.

It is my pleasure and privilege to be the President of AMCOW when this vital document is released. It is also my hope that its contents will provoke ongoing and fruitful discussions in our classrooms, villages, conference halls and national Parliaments on how best we can manage our African water resources and achieve our sanitation targets for the benefit of all.



Hon. Buyelwa Patience Sonjica
Chairperson of AMCOW and Minister for Water and Environmental Affairs, Republic of South Africa

Statement from Mr. Achim Steiner
UN Under-Secretary General and Executive Director UNEP

The seventh Millennium Development Goal (MDG No. 7) is to Ensure Environmental Sustainability. Its success is measured by targets for achieving sustainable development, reversing the loss of environmental resources, accessing safe drinking water and sanitation and significantly improving the lives of at least 100 million slum dwellers by 2015.

The debate that anchored MDG No. 7 climaxed during the RIO+10 World Summit on Sustainable Development (WSSD) in 2002 in South Africa. It was during this meeting, focused on "Equitable and sustainable use and the protection of the world's freshwater resources as a key challenge", that President Nelson Mandela underscored "the centrality of water in the social, political and economic affairs of a country, the continent, and indeed the world". It was also at this event that Secretary General Kofi Annan's keynote address anchored water in its relevance to energy, health, agriculture and biodiversity.

Africa is often characterized as a dry and arid continent where rainfall fundamentally limits water supplies. This pioneering Atlas and its continental and countrywide assessments challenge this widely-held view. Indeed, as is the case with energy, the problem is rather a question of access. Water resources can be more equitably shared if supplies are better managed for quality and quantity and more and smarter investments are made in sanitation, potable water and protecting ecosystem services that are the very foundation of water resources.

This Africa Water Atlas, the product of the Africa Ministers Council on Water (AMCOW), points to a suite of opportunities that offer a way from a situation of water scarcity to the implementation of strategies that can contribute to sustainable development and improve the likelihood of meeting the MDGs. Rainwater harvesting, for example, is one rapid way to improve water storage in rural as well as urban areas.

In Ethiopia, for example, just over a fifth of the population has access to domestic water supplies and an estimated 46 per cent of the population suffers from food insecurity. On the other hand, its rainwater harvesting potential could provide for the needs of over 520 million people. Evidence elsewhere shows that investing in forests can also generate significant returns, including maintaining and enhancing water supplies.

A recent assessment by the Government of Kenya, with assistance from UNEP, illustrates the value of protecting the forests that help to store water: it estimates that the ecosystem services provided by the Mau forest complex may be worth around US$1.5 billion a year. The Mau Forest Ecosystem, like many other water towers in Africa, provide services that include stabilizing soils, storing carbon and regulating water flows to some 12 major rivers that feed many lakes in the Great Rift Valley of Africa. These rivers and lakes supply drinking water, are harnessed for hydropower and engineered for irrigation and other key services that contribute to the economy and human well-being.

Rethinking agriculture and irrigation is also among Africa's water-related challenges. A recent survey of small-scale farmers in Africa who have switched to organic or near-organic practices found that yields rose by around 100 per cent—in part because of organic matter that improves soil moisture and lengthens the growing season.

The Africa Water Atlas crystallizes the realities and these myriad opportunities in a way that all readers can appreciate. Previous UNEP-supported atlases on Africa, including the Kenya Atlas of Our Changing Environment, have sparked real and tangible action including efforts to rehabilitate the Mau Forest Ecosystem and restore Lake Faguibine in Mali. I am confident that this Africa Water Atlas has the power to trigger debate and guide initiatives that will promote regional peace and the sustainable development of water resources.

Mr. Achim Steiner
Executive Director of UNEP

Statement from H.E. Jean Ping
Chairperson of the African Union Commission

At the WaterDome during the 2002 World Summit on Sustainable Development (WSSD), the text of the MDG No. 7 was reviewed and modified to strengthen metrics to monitor progress towards achieving water targets, incorporating sanitation as an integral part. The clarion call was to reduce by half the proportion of people without access to safe drinking water and adequate sanitation by 2015. In answer to this call, financial commitments were made through political pronouncements, the mood was carnival, and leaders seized these moments to reassure the world they were committed to making a difference.

The WaterDome at the WSSD provided an opportunity for stakeholders and investors to enter into a dialogue on the water agenda. Several initiatives were announced, including the European Union Water Initiative that established a working relationship with the African Ministers Council on Water (AMCOW). Other partners have since joined the partnership, including the African Development Bank, the German Development Cooperation (GTZ) and the Global Water Partnership (GWP), among others. The United Nations agencies led by UNEP have played a pivotal role through the UN Water/ Africa Forum.

To give the water agenda the necessary momentum, the Secretary General constituted the United Nations Secretary General Advisory Board on Water and Sanitation (UNSGAB). UNSGAB has been working closely with the African Water Facility hosted by the African Development Bank. Many other fora have been created as vehicles to support the achievement of water and sanitation targets in Africa.

The debate on water rights and access in Africa is centuries old. The history of the Nile River as the lifeline of riparian communities, beginning with the ancient Egyptian civilization and its modernized agriculture epitomizes the debate. The Nile underscores the importance of water resources for national security and community livelihoods. It is for this reason that treaties have been signed to secure the river's regular flow from its sources. Similar debates are commonplace in most of dryland Africa.

Countries like Libya have invested heavily in harnessing groundwater from the Nubian Sandstone Aquifer, thereby creating the largest man-made river in the world. On a smaller scale, water continues to be a major source of conflict amongst nomadic and pastoral communities in Africa. In urban areas, water is not only scarce for the poor, but costs up to five times more compared to affluent neighbourhoods. The Atlas also covers these issues, illustrating them with case studies and with the ample use of maps and other informative graphics.

Water issues in many parts of Africa can be emotive and politically divisive. Aware of the potential danger of regional conflict over shared waters, the African heads of state and governments provided leadership and mandated their water ministers to seek dialogue through a pan-African platform to make the water agenda a unifying factor for regional cooperation and integration. One of this Atlas's important features is a Chapter on transboundary water basins that points to the issue of shared water as a catalyst for cooperation among riparian countries. It also notes that the emergence of transboundary basin organizations in many of Africa's large basins may provide a powerful opportunity to build an enabling environment as a foundation for cooperation on numerous fronts.

When the President of the Federal Republic of Nigeria, H.E. Olusegun Obasanjo, launched the African Ministers Council of Water (AMCOW) on 22 April 2002 in Abuja, he was well aware of the gravity of the water issue. To ensure stability, President Obasanjo offered that Nigeria take on the role of host to the AMCOW Secretariat. AMCOW has since evolved, and is now recognised in the African Union as a Specialised Technical Committee under the Commissioner for Rural Economy and Agriculture.

As heads of state and governments continue to engage with high-level panels such as the G7 Summit and participate in debates that focus on Africa, it is imperative that the role of the private sector is emphasised in improving water and sanitation technologies through investment in research and development on the continent. The private sector can also invest in infrastructure development such as electricity, irrigation, industry and tourism. This Atlas supports such initiatives.

Because many people in Africa still lack access to potable water and adequate sanitation, one chapter in the Africa Water Atlas has been devoted to profiles of the water situation in each of Africa's 53 countries. This chapter gives a snapshot of the progress each one is making in achieving the water-related MDG targets, and reveals that although Africa has increased access to drinking water sources and sanitation facilities, general developments are not keeping up with population growth and economic activity.

This Africa Water Atlas balances the many challenges Africa faces in dealing with its water problems by stressing the opportunities to improve access to adequate and clean water. The Atlas identifies opportunities that exist to support exciting innovations, such as revolutionizing toilets so that all communities are served, promoting a Green Revolution that is "greener" and more sustainable than its post-World War II predecessor, investing in small-scale hydro and fostering the greening of the Sahel.

I wish to encourage all policy makers in Africa, including diplomats represented at the African Union, to embrace this Africa Water Atlas as a crucial reference document for informed decision-making. I also wish to thank UNEP, USGS, the European Union Commission, and all other partners who have played a part in the development of this seminal document that will accelerate the pace of cooperation and development on the water front in Africa.

H.E. Jean Ping
Chairperson of the African Union Commission

Executive Summary

This Atlas is a visual account of Africa's endowment and use of water resources, revealed through 224 maps and 104 satellite images as well as some 500 graphics and hundreds of compelling photos. However the Atlas is more than a collection of static maps and images accompanied by informative facts and figures: its visual elements vividly illustrate a succinct narrative describing and analyzing Africa's water issues and exemplifying them through the judicious use of case studies. It gathers information about water in Africa and its role in the economy and development, health, food security, transboundary cooperation, capacity building and environmental change into one comprehensive and accessible volume. UNEP undertook the production of this Atlas at the request of the African Ministers' Council on Water (AMCOW) and in cooperation with the African Union, European Union, United States State Department, United States Geological Survey and other collaborators.

The Atlas tells the paradoxical story of a continent with adequate renewable water resources, but unequal access because water is either abundant or scarce depending on the season or the place. Water is the most crucial element in ensuring livelihoods since more than 40 per cent of Africa's population lives in arid, semi-arid and dry sub-humid areas and about 60 per cent live in rural areas and depend on farming for their livelihoods. This particular story is complemented by the encouraging revelation that although rain-fed agriculture is widely constrained, there are also many dry areas where long-practiced and new water-harvesting strategies can be expanded.

The Atlas also tells stories for each of 53 countries, highlighting the salient water issues each faces and tallying the progress they have made towards the Millennium Development Goals' water-related targets. They underscore the still highly inadequate access to potable water and proper sanitation in most countries. These stories are also complemented by useful information about novel strategies and tools that could help to overcome obstacles (from physical, to technical and political) to achieving these targets.

These examples demonstrate that this Atlas is an important tool for decisions makers because it provides clues to address Africa's most challenging water issues.

Special Feature: Hotspots to hopespots and water towers

The Atlas's four chapters are preceded by a Special Feature that focuses on the often two-sided nature of water issues in Africa: surplus and scarcity, under-developed and over-exploited and challenges and opportunities. It makes a unique contribution to the knowledge of water issues on the continent by balancing the recognition of "hotspots" where rain-fed agriculture is highly constrained and food security is tenuous with the identification of "hope spots". These are places where substantial settlements in arid and semi-arid areas coincide with adequate rainfall for water harvesting. Here, traditional and new ways to collect and store water, such as the widespread construction of small farm ponds, could be expanded to support fragile livelihoods, especially in light of the probable impacts of climate change. The Atlas displays the wide distribution of these hope spots on maps generated using datasets of rainfall, soil texture, potential evapotranspiration, topography, landcover and population. Since ninety-five per cent of sub-Saharan Africa's farmland relies on rain-fed agriculture, and agriculture is the single most important driver of economic growth, improving food security through these techniques could very broadly improve human well being in many of Africa's drylands.

The Feature also draws attention to Africa's "water towers". These are forested uplands in several African watersheds, including transboundary basins. They store water and contribute disproportionately to the total stream flow of Africa's major rivers that supply water for hydropower, wildlife and tourism, small- and large-scale agriculture, municipalities, transportation and ecosystem services. Implementing Integrated Water Resources Management (IWRM) could help protect these water towers and sustainably develop their concentrated water resources, especially when two or more countries share them and when upstream activities affect downstream water needs.

Chapter 1: Water resources

The first chapter provides the geographical foundations of water quantity, quality and distribution across Africa's diverse regions. From North Africa to the island countries, it uses various measures to illustrate Africa's hydrological characteristics by charting and mapping water resources at the continental scale. Topics include Africa's overall water resources (lakes and impoundments, rivers, estuaries, wetlands, groundwater and aquifers, etc.), water distribution across the continent and access to that water, the physical setting within which water is found and the climatic conditions that deliver essential rainfall.

After Australia, Africa is the world's second-driest continent. With 15 per cent of the global population, it has only 9 per cent of global renewable water resources. Water is also unevenly distributed, with Central Africa holding 50.66 per cent of the continent's total internal water and Northern Africa only 2.99 per cent. In addition, Africa's climate is highly variable over the seasons. Africa's water availability is also constrained by its groundwater resources, which represent only 15 per cent of total renewable water resources, but supply about 75 per cent of its population with most of its drinking water. Thus, in all regions except central Africa, water availability per person is under both the African and global averages. Africa's annual per capita water availability is lower than that of all of the world's other regions except Asia, the most populous continent.

This chapter is careful to note, however, that differences in water availability and access in African countries does not simply depend on natural conditions—they are influenced by the number of people using that water and compounded by increased water demand because of growing populations, especially in peri-urban areas and slums (between 2005 and 2010, Africa's urban population grew at a rate of 3.4 per cent, or 1.1 per cent more than the rural population), and due to higher standards of living in some population segments; weak city planning and water and sanitation management; a lack of resources; and competition for available freshwater between sectors such as industries, municipalities, agriculture and tourism and often between upstream and downstream users. The chapter also explores the relationship between water and poverty. For example, widespread poverty constrains many communities' ability to address water issues even when significant opportunities such as irrigation, rain-water harvesting, groundwater exploitation or sanitation infrastructure exist. Finally, it looks at the relationship between water and gender, noting that the burden of water collection in Africa falls disproportionately on women and girls, who in some cases spend as much as 40 per cent of their caloric intake carrying water.

Chapter 2: Transboundary water resources

Africa's many borders and its geography pose a challenge to equitably sharing and developing its water resources. Chapter two focuses on water at the scale of major watersheds and groundwater basins that cross national boundaries. Africa's 63 international river basins cover about 64 per cent of the continent's land area and contain

93 per cent of its total surface water resources. They are also home to some 77 per cent of the population.

Chapter two provides in-depth profiles of 13 major transboundary surface-water and 5 shared groundwater basins, illustrated with satellite images, maps and pictures. The groundwater basins represent various regions on the continent, with special emphasis on the Nubian Sandstone Aquifer System, Africa's largest aquifer. Satellite images in time series show striking cases of environmental change within the basins over the past several decades, including landscapes in which lake areas have declined dramatically, dams have created huge artificial lakes, deltas are sinking, saltwater is invading coastal aquifers, transboundary wetlands are shrinking and irrigated agriculture has created spherical green oases in deserts. The case studies examine issues such as water budgets and water quality, irrigation, transport, fisheries and agriculture, invasive species, population growth and development projects including dams and diversions, among others. They analyse past and present conditions, the drivers of change, environmental and social impacts of water development schemes and aspects of transboundary water management. One of the chapter's conclusions is that the need to share water among riparian nations is often a catalyst for effective cooperative water management, rather than the source of conflict.

Chapter 3: Water challenges and opportunities

Chapter three examines nine challenges and opportunities facing Africa as it strives to improve the quantity, quality and use of its water resources. Each of the nine issues is presented by discussing the challenge, the situation, the constraints and the opportunities.

1. The first challenge is to attain the MDG water-provision target of reducing by half the proportion of the population without sustainable access to drinking water by 2015. Africa as a whole will not reach this target and only 26 of the 53 countries are on track to attain it. Opportunities to address this challenge include the targeting of informal and rural settlements and adopting and expanding simple but proven technologies such as a water-disinfection system that already provides drinking water to about four million people.

2. Improving access to clean water will help achieve the second challenge, which is to reduce by half the proportion of the population without sustainable access to basic sanitation by 2015. Of Africa's 53 countries, only nine are expected to attain this target. Opportunities include the potential to encourage and support simple entrepreneurial solutions and to embark on a new drive to revolutionize toilets so they are as desirable as mobile phones.

3. Africa has 63 shared water basins, so it is a challenge to address potential conflicts over transboundary water resources. On the other hand, there are already at least 94 international water agreements in Africa to cooperatively manage shared waters. There is thus an opportunity to learn from their successes and to build on water as a binding factor.

4. Water scarcity challenges Africa's ability to ensure food security for its population. Agriculture uses the most water in Africa and the estimated rate of agricultural output increase needed to achieve food security is 3.3 per cent per year. The potential for meeting this estimate exists, however, since two-thirds of African countries have developed less than 20 per cent of their agricultural production and less than 5 per cent of cultivated area is under irrigation in all but four countries. There is also the opportunity to promote a greener more sustainable version of the Green Revolution, including investments in simple and inexpensive irrigation technologies and breeding drought-tolerant crop varieties.

5. Hydroelectricity supplies 32 per cent of Africa's energy, but its electricity use is the lowest in the world. Africa's hydropower potential is under-developed, however, and hydropower development potential is greater than the entire continent's electricity needs. There are opportunities to develop this untapped resource, but it should be done in ways that avoid the environmental and human costs associated with large dams.

6. Africa faces the challenge of providing enough water for its people in a time of growing demand and increased scarcity. But Africa is endowed with large and often under-utilized aquifer resources that contain excellent quality water and could provide water security in times of drought. There is also the opportunity to improve water-use productivity rather than develop new sources.

7. Land degradation and water pollution reduce water quality and availability. These challenges could be addressed by efforts to maintain vital ecosystem functions, fostering the greening of the Sahel by encouraging adaptation to drought and encouraging adaptive water management strategies.

8. Africa is one of the most vulnerable continents to climate change and climate variability. Given the inherent inter-annual rainfall variability, people in arid and semi-arid lands have a long history of traditional adaptation mechanisms that could be reinforced and adjusted to new circumstances. In addition, there is the opportunity to provide more and better early warning mechanisms.

9. Africa faces a situation of economic water scarcity, and current institutional, financial and human capacities for managing water are lacking. The opportunities for addressing this challenge include reforming water institutions, improving public-private partnerships and expanding the knowledge base through human capacity building.

Chapter 4: Water profile of each country

The final chapter is a country-by-country look at water availability and withdrawals, irrigation and water use by sector. Two of the most important water issues in each country are identified and discussed. The country profiles also summarize progress toward the MDG water targets. The MDG summaries frequently highlight the difference between water and sanitation provision in urban versus rural areas. In general, they reveal that the greatest challenges in attaining the targets are not environmentally deterministic; rather, they have to do with political unrest and conflicts that have damaged water and sanitation resources or prevented their development; the influx of people to burgeoning cities and slums; and a lack of resources to support water-management capacity, or simply weak management.

The Atlas is a significant and timely contribution that can inform the implementation of commitments made in the Africa Water Vision 2025. Among other goals, the Vision indicates the minimum need to double the area under irrigation and develop 25 per cent of Africa's hydropower potential. Decision makers can also look to the Atlas for background information and tools to assist in fulfilling commitments made in other recent events and declarations. These include the 2008 Ministerial Conference on Sanitation at eThekwini, where ministers pledged to adopt national sanitation and hygiene policies within 12 months and to ensure these are on track to meet national sanitation goals and the MDGs by 2015; the organization of the First African Water Week and Ministerial Declaration in Tunis; the African Union (AU) Summit's dedication to water and sanitation in June 2008 at Sharm El Sheikh; and the Ministerial Meeting on Water for Agriculture and Energy at Sirte.

We never know the worth of water till the well is dry.

~Thomas Fuller, Gnomologia, 1732

Joachim Huber/Flickr.com

SPECIAL FEATURE
WATER "HOTSPOTS" TO "HOPESPOTS", AND WATER TOWERS OF AFRICA

The title of this special section highlights the often two-sided nature of water issues in Africa: positive and negative, scarcity and surplus, over-exploited and under-developed, challenges and opportunities. It looks at the challenges and opportunities inherent in two quintessential African water issues—uneven spatial distribution of resources and temporal rainfall variability. The two vignettes present both the troublesome and hopeful sides of these two issues.

Hotspots to Hopespots

Over 64 per cent of Africa's population is rural (World Bank 2008), with much of that number living on small subsistence farms. Ninety-five per cent of sub-Saharan Africa's farmland relies on rain-fed agriculture (Wani and others 2009), making most people heavily dependent upon each year's rainfall pattern. For smallholder farms, timely and adequate rains are vital for livelihoods and food security. In some areas, such as West Africa where 80 per cent of employment is in the agriculture sector (Barry and others 2008), timely rainfall is central to the entire economy. However, Africa experiences remarkable variability in rainfall at inter-annual, decadal and longer time scales (Nicholson 1998, Nicholson 2000, Peel and others 2001). This is of particular concern in arid and semi-arid zones where rain-fed agriculture is marginal.

Hotspots

Researchers have consequently identified Africa as one of three global "hotspots" for water-constrained, rain-fed agriculture. They find that people living in these "hotspot" environments are disproportionately undernourished and they link it to climate-driven food insecurity. Most of the 100 million people in Africa living in these areas of water-constrained, rain-fed agriculture are found in a band running through Senegal, Mali, Burkina Faso, Niger, Nigeria, Chad, Sudan, Ethiopia, Somalia, Kenya, Tanzania, Zambia, Malawi, Mozambique, Zimbabwe and South Africa (Rockström and Karlberg 2009). The red hatching on Figure i shows the areas within Africa's arid and semi-arid regions (Trabucco and others 2009) with populations of 20 persons per km^2 or more (ORNL 2008). These are generally the areas in which food security is most tenuous in Africa.

E. Muench / Flickr.com

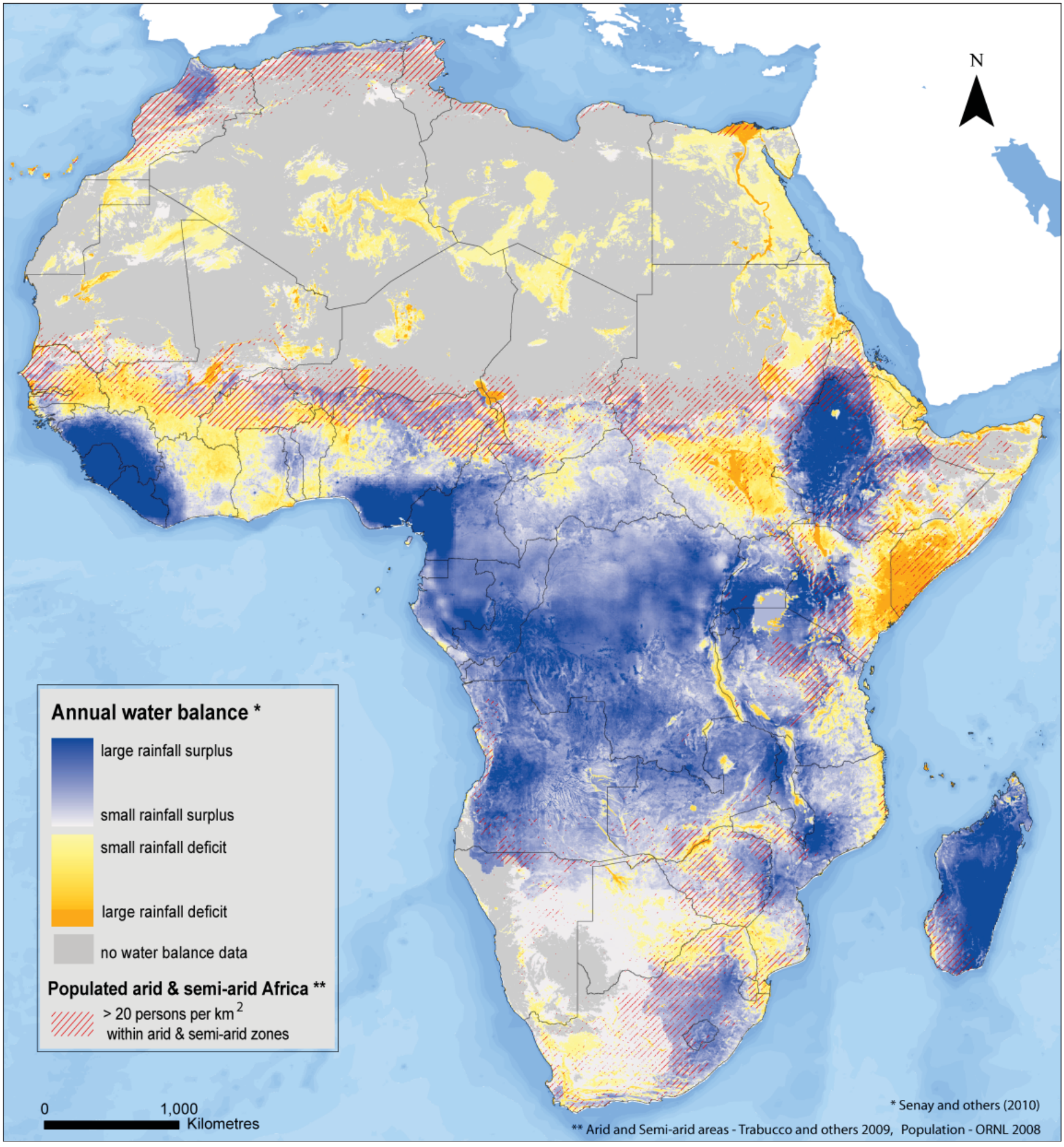


Figure i: Annual water balance is an estimate of the available runoff after evapotranspiration—water that is potentially available for water harvesting. The red hatching overlaying the water balance map shows where population density of greater than 20 persons per km² coincides with areas defined as arid or semi-arid

Water Balance

Hydrologists model Africa's surface water systems using data sets describing precipitation, temperature, evapotranspiration, topography, soils and human-made diversions and impoundments. Recent research has used satellite data to more accurately quantify land-surface processes across the African continent, and in turn, to better estimate vegetation water use. Combined with climate data, this produces a map of "evapotranspiration"—an estimate of the sum of surface evaporation and plant transpiration. This data layer has been used to more accurately generate a water balance map (rainfall minus the water lost to evapotranspiration) as shown in Figure i. This water-balance data is used to model surface water and groundwater behaviour, including stream flow and the potential for dams and other forms of water harvesting.

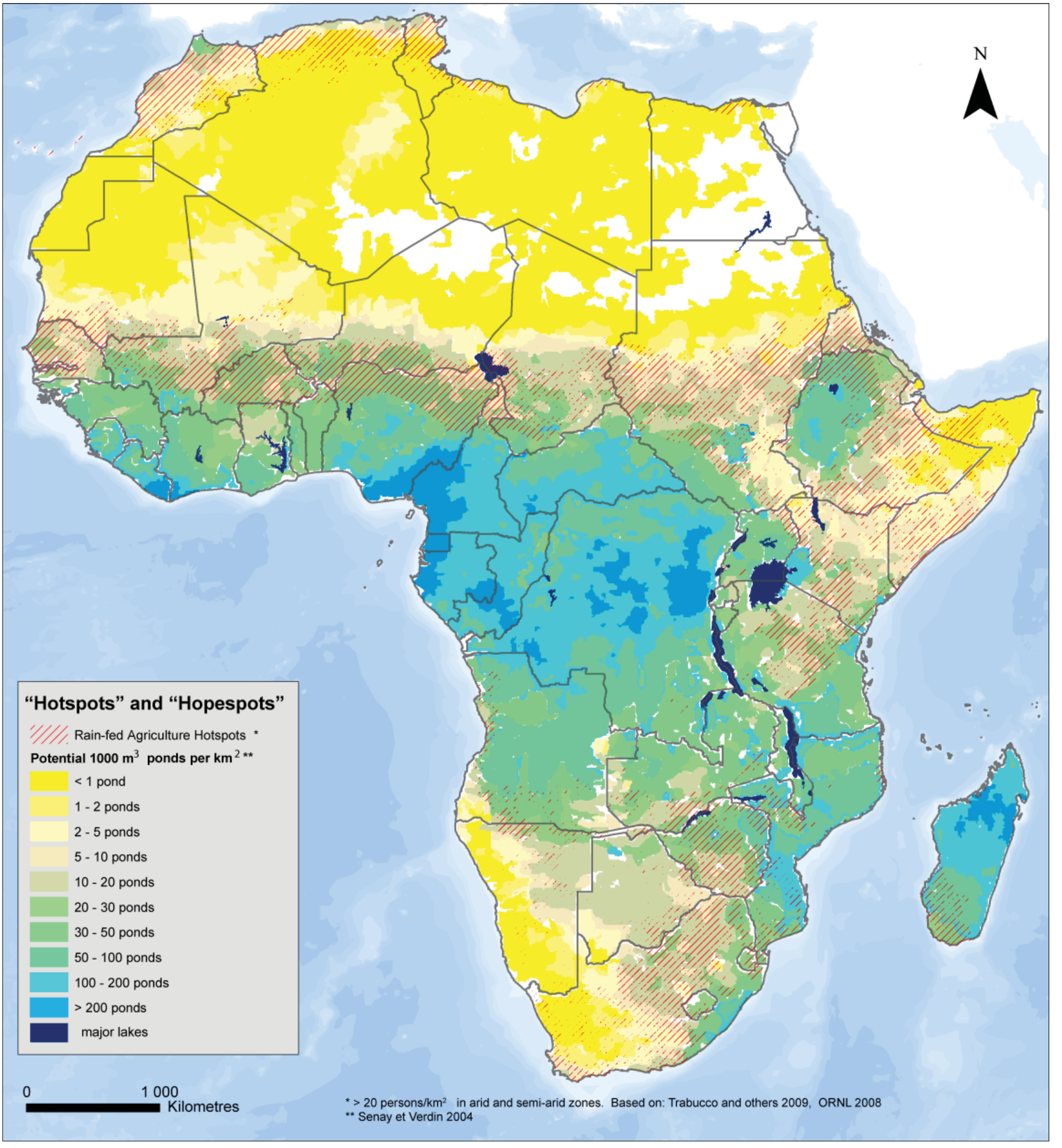
Hopespots

One coping strategy in these drought-prone environments is rainwater harvesting. This can take many forms—from large-scale dams that provide regional benefits to the simple collection of rainwater in a barrel to sustain a household garden through dry periods. For smallholder farms, indigenous techniques for collecting and storing water or enhancing soil moisture are already used in many locations (Barry and others 2008). Expanding these practices and adopting new techniques could make a very significant difference in agricultural production and household food security. Constructing small ponds to collect runoff is an effective practice that has been used in eastern and southern Africa to reduce the risk of crop failure and increase production. This water is then available for multiple uses, such as watering vegetable gardens and smallholder farm fields during water-stressed periods (Rockström 2000).

Researching where this approach is best suited could provide a tool for identifying some "hopespots" where this simple technique can be applied by many smallholder farms (Senay and Verdin 2004).

Lamu District, Kenya—water harvesting pond

Figure ii: Areas of population density greater than 20 persons per km² that coincide with arid and semi-arid zones are potential hotspots of vulnerability for water-constrained rain-fed agriculture (red hatch marks). Many of these areas have adequate runoff for filling small farm ponds, which can reduce vulnerability and improve food security (Senay and Verdin 2004)



This concrete slab in northeastern Kenya collects rainfall and diverts it into an underground storage tank for later use

Water harvesting pond under construction in Lamu District, Kenya

Using datasets for rainfall, soil texture, potential evapotranspiration, topography, landcover and population, researchers have produced a set of maps identifying these potential areas (Senay and Verdin 2004). Figure ii is a broad picture of areas with high potential for this type of technique. Places where these "hopespots" coincide with populated areas in arid and semi-arid Africa (red crosshatches) might be starting points for introducing small farm ponds and other rainwater harvesting techniques that could make a big difference in the lives of rural people.

Because urban areas have less watershed area per person from which to collect water, there is less potential for rainwater harvesting (Senay and Verdin 2004). Nevertheless, water collection from urban watersheds as small as household rooftops can provide valuable water for maintaining urban and peri-urban farming and for domestic use (Kahinda and others 2007, Kabo-Bah and others 2008).

Hope in Action

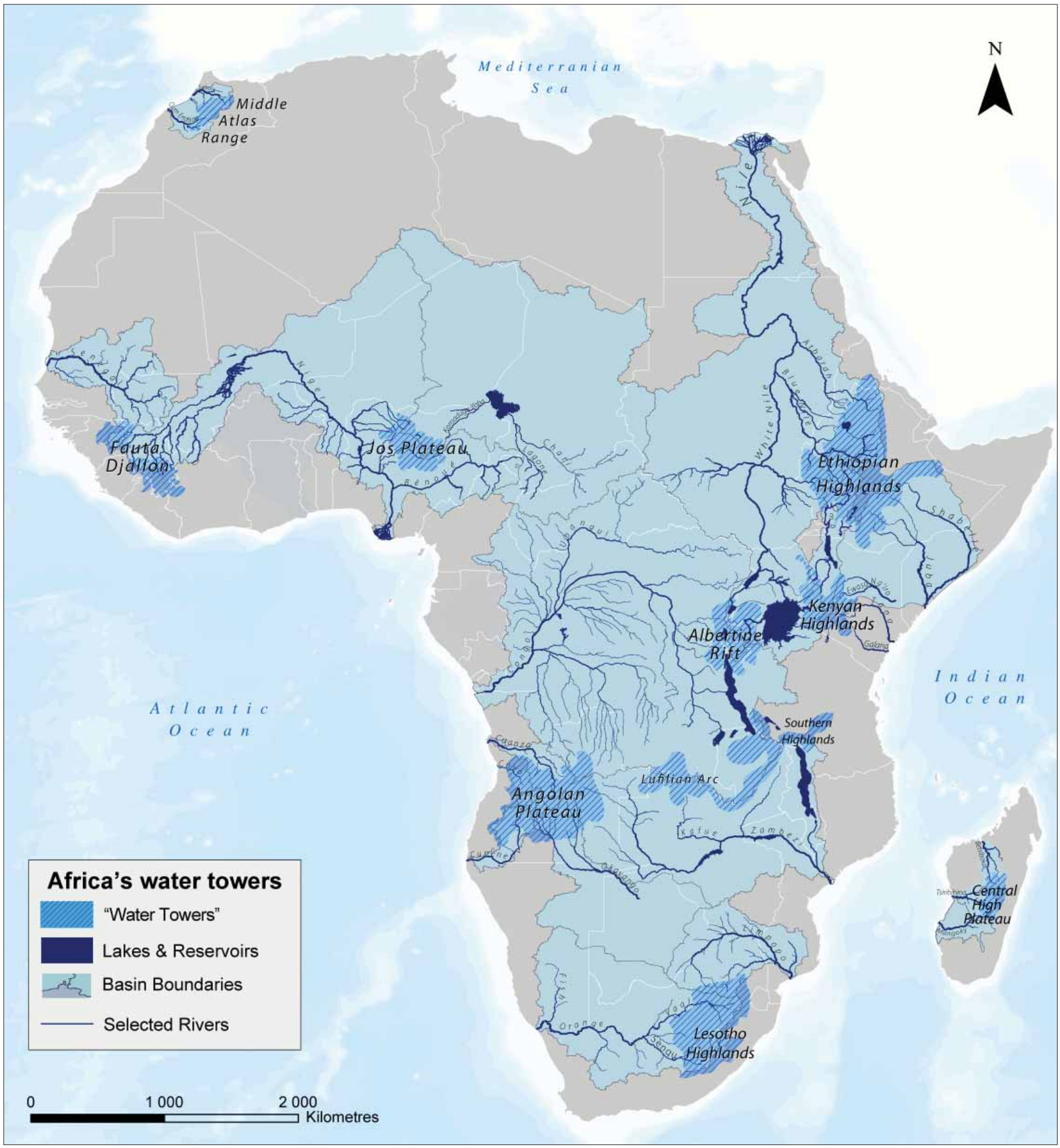
Many areas in the Greater Horn of Africa are "hotspots of water-constrained rain-fed agriculture" (Rockström and others 2009). However, the successful use of rainwater harvesting in many locations across the region is already mitigating the risk for farmers and helping to reduce food insecurity in their communities (USAID 2009, Barron 2004, Pachpute and others 2009). There are numerous examples of successful rainwater harvesting projects in the region, particularly in Kenya, including the use of small farm ponds like those already mentioned. Above are some images from these bright spots of hope.

Water Towers of Africa

Mountainous and other elevated areas in several African watersheds contribute disproportionately to the total stream flow of Africa's major rivers. These areas generally receive more rainfall than their lower surroundings. They also usually lose less water to evapotranspiration because temperatures are lower. Downstream areas often benefit from the abundant runoff. Rivers such as the Nile, the Niger, the Senegal and the Orange flow from relatively rain-abundant areas to areas that would otherwise be too arid to support much life. These important, high-elevation watersheds have been referred to as "the water towers of Africa" for the role they play in supplying millions with life-giving water. The Millennium Ecosystem Assessment (MA) states that mountains act as water towers by storing water in glaciers, permafrost, snow-packs, soil or groundwater (MA 2005).

These "water towers" are sources for many of Africa's transboundary rivers. This can mean upstream communities influence the management of life-giving resources in downstream areas. In many cases, these "water towers" are within multi-national watersheds. While this is sometimes a source of tension, it has seldom led to all-out armed conflict. In fact, it has often proven to be an opportunity for cooperation (Wolf 2007).

Figure iii shows several of Africa's "water towers." They were identified by relative elevation (generally 200–800 m above the surrounding area); precipitation above 750 mm; and runoff above 250 mm. They were also selected for the contribution they make to water resources for populations beyond their delineated boundaries



Several of Africa's transboundary basins are already under the oversight of basin management organizations, such as the Niger Basin Commission in West Africa. Organizations such as these are tasked with presenting their constituent national governments with the science-based understanding of resources shared within these major surface water basins. In this way, the "water towers" concept can complement Integrated Water Resources Management (IWRM) processes by identifying important source areas within major watershed basins. These areas of concentrated resources can then be protected and sustainably developed to equitably address food security, economic development and environmental issues for all stakeholders.

Kenya's Five Water Towers

The five "water towers" of Kenya—Mount Kenya, the Aberdare Range, the Mau Forest Complex, Mount Elgon and the Cherangani Hills—are montane forests and the country's five largest forest blocks. They form the upper catchments of all the main rivers in Kenya (except the Tsavo River originating in Mt. Kilimanjaro). The "water towers" are sources of water for irrigation, agriculture, industrial processes and for all installed hydropower plants, which produce about 60 per cent of Kenya's electricity output. These montane forests are also surrounded by Kenya's most densely populated areas, because they provide enough water for intensive agriculture and urban settlements (DRSRS and KFWG 2006). The integrity of these forests affects their capacity to mitigate floods and drought, prevent soil erosion, maintain water quality, increase groundwater infiltration and influence the micro-climate in and surrounding the forest (GoK 2010).

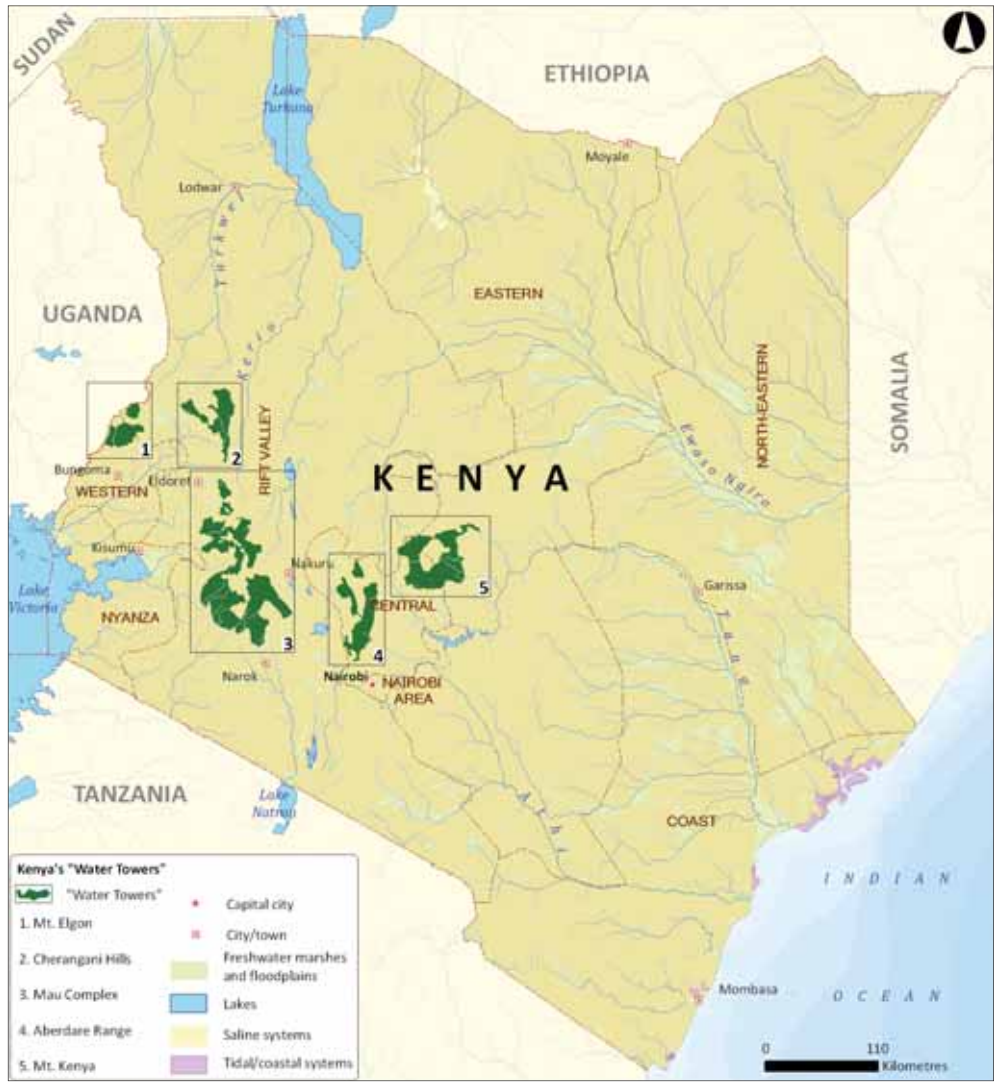


Figure iv: The five "water towers" of Kenya


Christian Lambrects /UNEP

Agricultural expansion into the Mau Forest Complex

Mau Forest Complex

The Mau Forest Complex, covering over 400 000 ha, is the largest of the five water towers. It is Kenya's largest closed-canopy forest ecosystem and the single most important water catchment in the Rift Valley and western Kenya. The Complex forms part of the upper catchments of all but one of the main rivers on the west side of the Rift Valley. These rivers act as arteries carrying the Mau's waters throughout western Kenya—from Lake Turkana in the north to Lake Natron in the south, as well as to Kenya's most populous rural areas in the Lake Victoria basin. These rivers support agriculture, hydropower, urban water supply, tourism, rural livelihoods and wildlife habitat throughout much of Kenya. As a part of the catchment for Lake Victoria and the White Nile, the Mau Forest is also of international importance, especially with respect to water quality.

In spite of its national importance, many areas of the Mau Forest Complex have been deforested or degraded; much of this damage has taken place in the past few decades. Degazettement of forest reserves and continuous widespread encroachment have led to the destruction of over 100 000 ha of


Eugene Apindi Ochieng

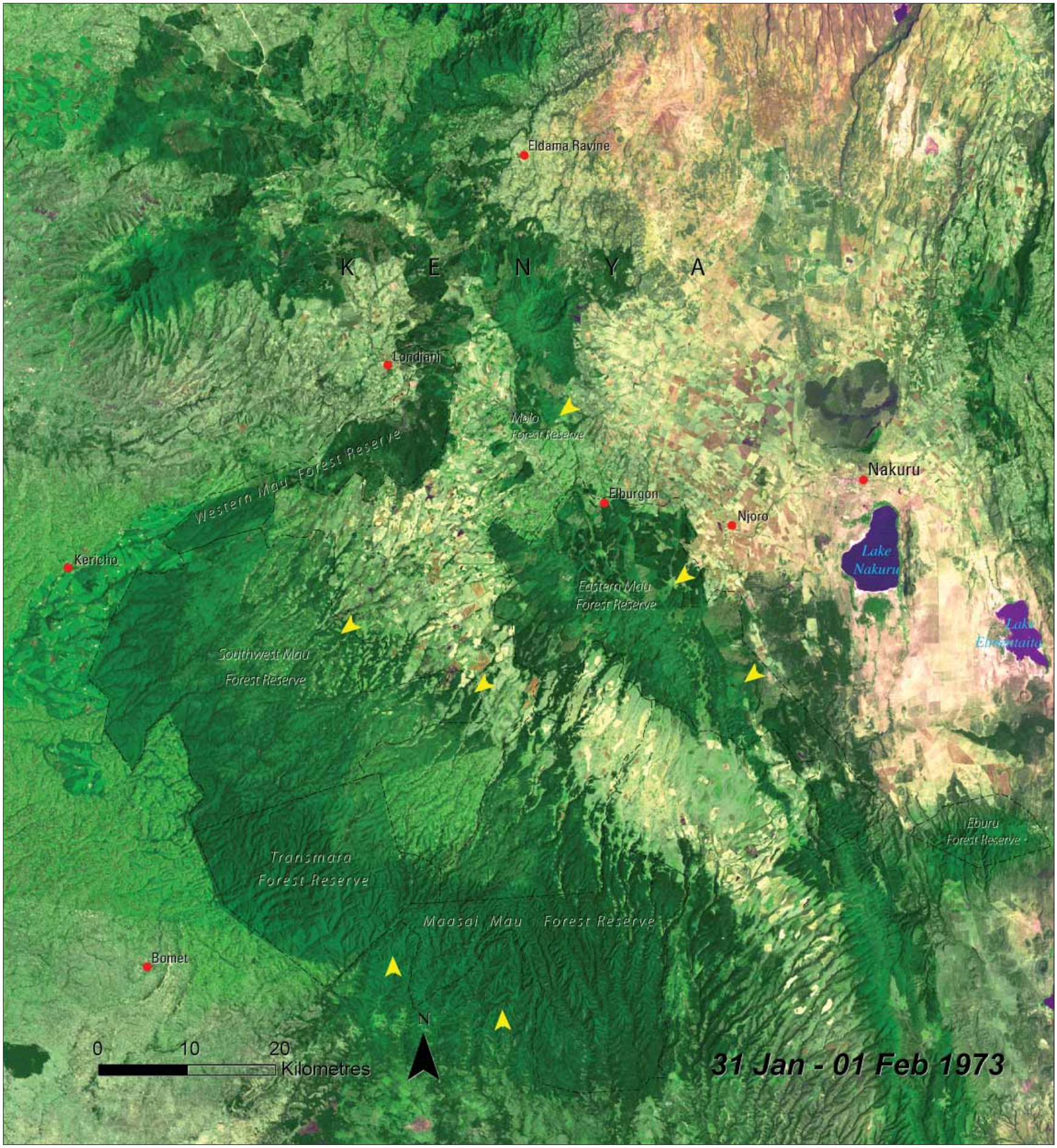


Figure v-a*:* Many areas of Kenya's Mau Forest Complex had already been converted to agriculture in the 1970s. Farm fields show as light and dark patches with straight edges between the dark-green forest areas

forest since 2000, representing roughly one-quarter of the Mau Complex's area (yellow arrows). The satellite images from 1973 and 2009 capture 36 years of forest loss in the Mau Complex.

Since the 1970s, Maasai Mau Forest has lost over 8 214 ha of forest within its official boundaries and another 32 000 ha outside the protected area. The eastern slopes of the Maasai Mau Forest are a crucial catchment for the Ewaso Ngiro River, as are the western slopes for the Mara River. The Mara River is a lifeline for Kenya's most famous tourist destination—the Maasai Mara National Reserve. In 2001 alone, over half of Eastern Mau Forest Reserve was excised. The Eastern Mau Forest is the headwaters for the Njoro River, which drains its eastern slopes into Lake Nakuru, another of Kenya's prime tourist attractions.

Also in 2001, one-quarter of the Southwest Mau Forest Reserve was excised. This forest reserve is the primary source of the Sondu River, site of the Sondu-Miriu hydropower plant. It is estimated that the Mau Forest catchments have the potential to generate over 500 MW of power or about 40 per cent

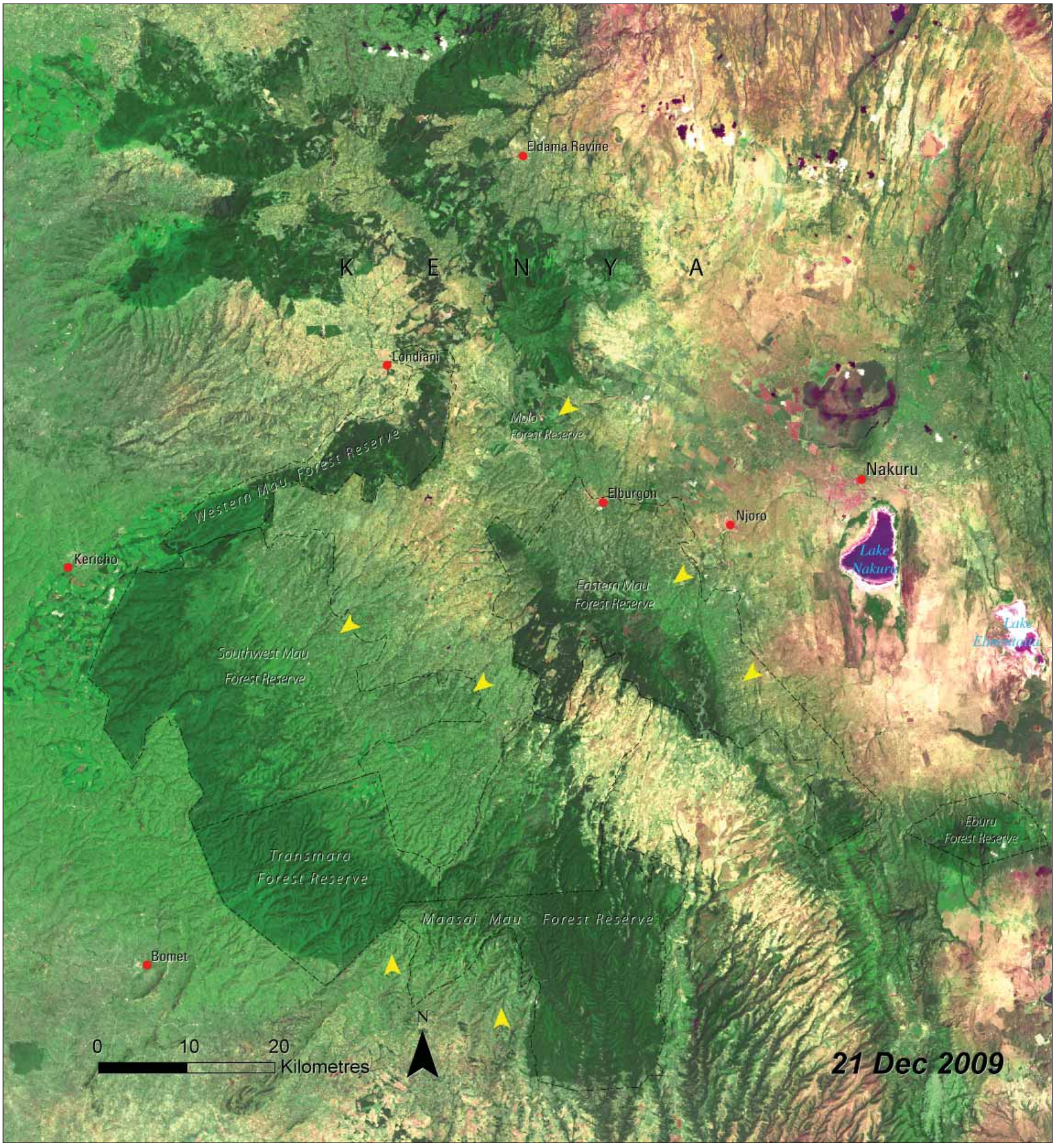


Figure v-b*:* By 2009, several additional large forest areas had been converted to agriculture—see areas indicated by the yellow arrows

of Kenya's current total generating capacity (GoK 2010). On the western edge of the Southwest Mau, the Kericho Highlands tea growing area depends on the montane forest's moderating influence on the micro-climate. Sale of tea from western Kenya was valued at roughly US$170 million in 2007 (GoK 2010).

Recognizing the threat that deforestation poses to these industries and a range of crucial ecosystem goods and services, the Kenyan government convened a forum in 2009 to find ways to address the health of the Mau Forest Complex. A plan to rehabilitate the forest was proposed, with a budget of US$81 million. By early 2010, a commitment of roughly US$10 million had been received from international donor governments (UNEP 2010). The Kenyan government's goal is to rehabilitate the Mau Forest and secure its watershed functions for Kenya and its neighbours (GoK 2010). A new understanding of the Mau Forest as a "water tower" with importance well beyond its immediate area helped mobilize resources and precipitated actions that may make rehabilitation possible.

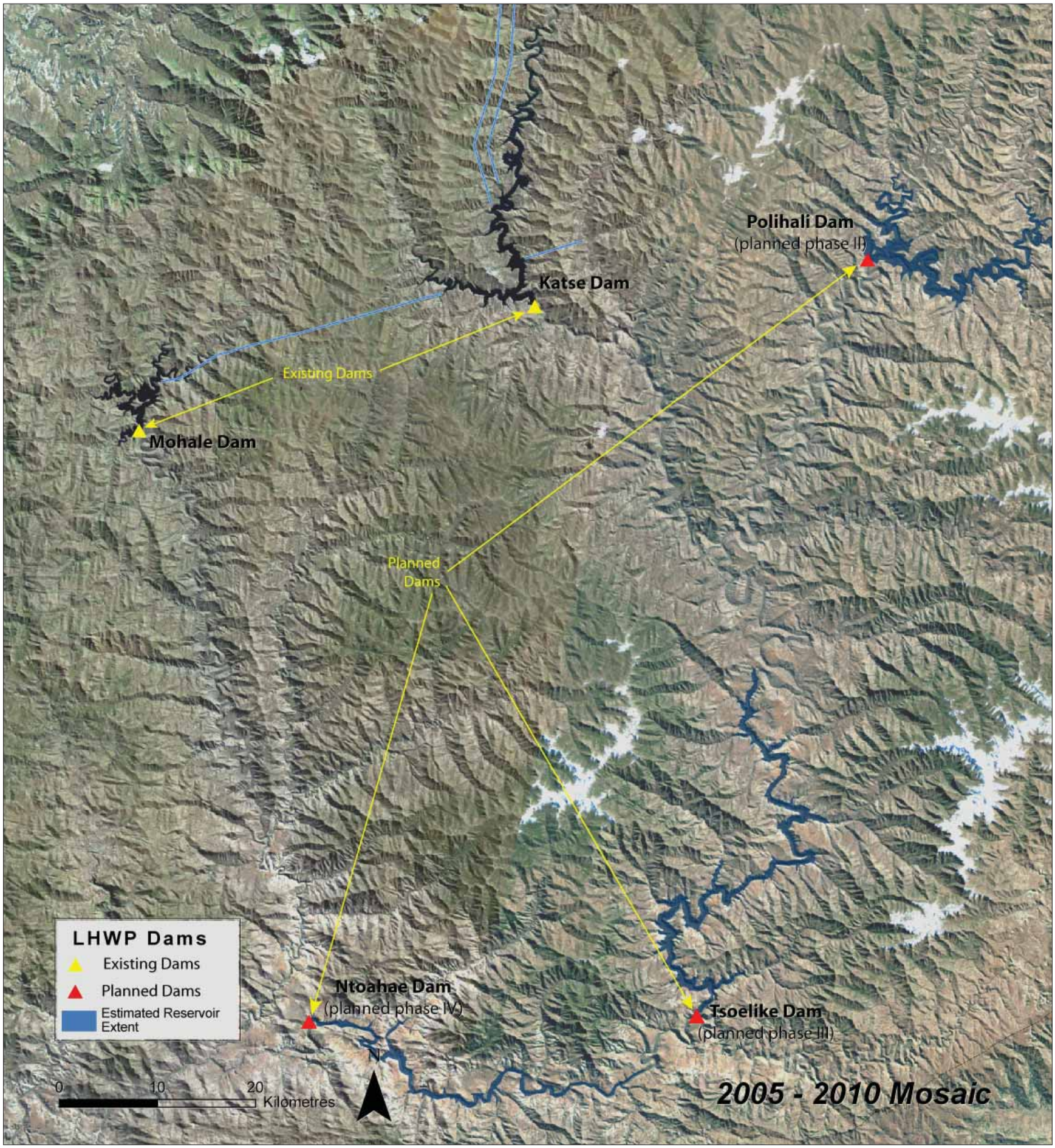


Figure vi: The Lesotho Highlands Water Project will construct several dams and transfer tunnels to generate power and move water to Gauteng Province, South Africa. Katse and Mohale Dams have been completed (yellow triangles). The location and projected reservoir footprints for three additional dams—Ntoahae, Tsoelike and Polihali—are also shown (red triangles)

Lesotho Highlands–A Water Tower in Southern Africa

The cool, wet and misty climate of the Lesotho Highlands makes them a more productive water catchment than the surrounding lower elevations (FAO 2006). Gauteng Province, 250 km to the north, is South Africa's largest urban and industrial centre. In the 1950s, the proximity of these water-rich highlands to thirsty Gauteng Province inspired the idea of using the Lesotho Highlands as a "water tower" (LHDA n.d.).

In 1986, a treaty signed by South Africa and Lesotho initiated the Lesotho Highlands Water Project. Its design included a total of five dams but committed the parties to only the first two dams and related infrastructure (IUCN n.d.) at a cost of over $US1.4 billion (Matete 2006). Its purpose is to deliver water to Gauteng Province in the industrial heartland of South Africa and hydropower and cash to Lesotho (Matete 2006). In 1997, the 185 m Katse Dam was completed on the Malibamatso River; the Mohale Dam, 40 km to the west on the Senqunyane River, was completed in 2003 (LHDA n.d.). Phase II of the

Figure vii: Katse Dam site

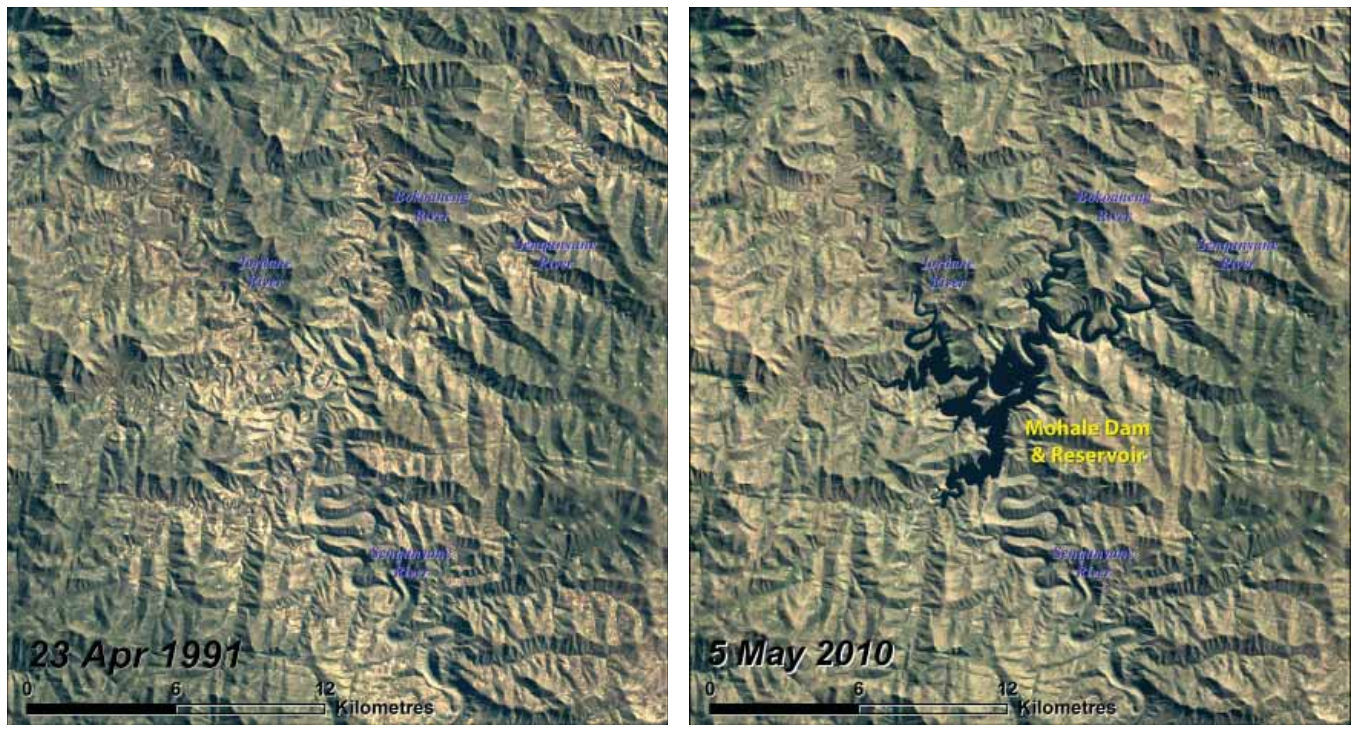


Figure viii: Mohale Dam site

The Katse dam reservoir

project has been revised in light of a recent feasibility study, replacing Mashai Dam and associated infrastructure by the Polihali Dam located just below the confluence of the Senqu and Khubelu Rivers, roughly 35 km east of Katse Dam (Tanner and others 2009). The existing dams, Katse and Mohale, and associated reservoirs can be seen in the upper-left third of the satellite image (Figure vi). The extent of reservoirs for Polihali Dam, Tsoelike Dam (phase III) and Ntoahae Dam (phase IV) have been estimated from digital elevation models and are overlain on the image.

The project has been controversial since it began, with concerns about the social and environmental costs. Katse Dam affected more than 20 000 people and Mohale affected 7 400, with impacts including loss of homes, farmland and communal grazing land (Devitt and Hitchcock 2010). Among the environmental concerns raised were impacts on downstream riparian and coastal habitats (Willemse 2007, IUCN n.d.). Failure to undertake an environmental flow assessment study of the project until 1997 (after the first phase of construction was complete) prevented design changes that could have mitigated downstream environmental impacts (IUCN n. d.).

The 1991 images (Figures vii and viii) show parts of the project area before Katse and Mohale Dams were constructed. The adjacent images from 2010 after both dams had been filled, show the area inundated. The Katse Dam and Muela Hydropower Facility (not shown), took approximately 1 900 ha of croplands out of use and the Mohale Dam removed a further 1 000 ha. The three dams combined decreased pastureland by 5 000 ha. In addition to the impact on the immediate area, approximately 150 000 more people are affected by reduced stream flow below the dams (Hoover 2001).

1 WATER RESOURCES

William Warby/Flickr.com

In Africa, the world's second-driest continent, the availability and access to water is more crucial to existence than it is almost anywhere else on Earth. Poverty is widespread and although it is rapidly urbanizing, the majority of its population is still rural-based and dependent on agriculture. In sub-Saharan Africa, 69 per cent of the population has no proper sanitation facilities, while 40 per cent has no reliable access to safe water (WHO/UNICEF 2008). Thus, a large number of countries on the continent still face huge challenges in attempting to achieve the United Nations (UN) water-related Millennium Development Goals. Water plays a central role in development, covering a broad cross-section of socio-economic aspects that include meeting people's basic needs, such as drinking and sanitation, demands from various economic sectors, food security, poverty, health, gender issues, governance issues, energy and transport. Water is indeed everyone's business, an essential resource to all aspects of society. In short, water is life.

Water Availability

Very little of the Earth's abundant water is actually accessible and suitable for human needs. This is especially true in Africa. At the continental level, Africa's 3 931 km^3 of renewable water resources represent around 9 per cent of the world's total freshwater resources; by comparison, South America and Asia have the highest proportion each with 28.3 per cent, followed by North America with 15.7 per cent, and Europe with 15 per cent (FAO 2009) (Table 1.1).

Africa is the world's second-driest continent, after Australia, but also the world's most populous continent after Asia. Table 1.1 shows that for the year 2008, the continental annual average water availability per person was 4 008 m^3, well below the global average of 6 498 m^3/capita/yr (FAO 2009).

Water Distribution

There are wide differences in natural water distribution within Africa's sub-regions. Central and Western Africa are endowed with the highest proportions at 51 and 23 per cent respectively, while the share is as low as 3 per cent for Northern Africa (Table 1.2).

A combination of human and natural factors is responsible for differences in water abundance within African countries. When actual total renewable water resources are considered, Nigeria appears to have an abundance of water resources, along with the Democratic Republic of Congo and Madagascar (Figure 1.1). However, average water availability depends not only on internal renewable water resources, but also on the number of people using that water.

Key Facts

Africa has only about 9 per cent of global freshwater resources but 15 per cent of the global population

Africa is the world's second-driest continent, after Australia

Africa's annual per capita water availability of 4 008 m^3 in 2009 is well below other world regions except Asia, the world's most populous continent

Table 1.1: Comparative table of internal renewable freshwater resources by world region (Source: FAO 2009)

Continent/Region	Volume per Year (km^3 or 10^9 m^3)	Percentage of World Freshwater Resources	Per Capita (m^3/year) (2008)
WORLD	**43 802**	**100.0**	**6 498**
Africa	3 931	9.0	4 008
Asia	12 393	28.3	3 037
South America	12 380	28.3	32 165
Central America & Caribbean	781	1.8	9 645
North America	6 877	15.7	15 166
Oceania	892	2.0	32 366
Europe	6 548	14.9	8 941

Key Facts

Renewable water resources are unevenly distributed among Africa's sub-regions

A combination of natural and human factors are responsible for wide differences in water availability between African countries

Table 1.2: Total and proportional renewable water resources in Africa's sub-regions (Source: FAO 2009)

Sub Regions	Total Water Resources (km^3/year) (2008)	Percentage of Internal Water Resources of Africa
Central Africa	2 858.08	50.66
Eastern Africa	262.04	4.64
Western Indian Ocean Islands	345.95	6.13
Northern Africa	168.66	2.99
Southern Africa	691.35	12.25
Western Africa	1 315.28	23.32
Total Africa	**5 641.36**	100

There are wide variations in average water availability per person among countries in the continent (Figure 1.2). For example, the annual per capita water availability for Nigeria, Africa's most populous nation, is lower than that of relatively dry states such as Botswana and Namibia in Southern Africa. Annual per capita water availability is high for countries such as Guinea, Sierra Leone and Liberia in West Africa; the Democratic Republic of Congo, Central African Republic and Gabon in Central Africa; and in the Indian Ocean island of Madagascar. In the southern part of the continent, water availability per capita is relatively low for South Africa, as it is in North African states such as Algeria and Libya, as well as Kenya in East Africa.

The unequal water distribution has significant implications for society, often causing widespread acute human suffering and economic damage on a continent where agriculture—largely rain-fed, is the single most important driver of economic growth (Conway and others 2009). In addition to high variability, rainfall across the continent is unpredictable, and characterized by high evaporation losses and low runoff (Batisani and Yarnal 2010, Slimani and others 2010). Groundwater reservoirs underlain by low-storage geological formations also depend on effective rainfall from unreliable rainfall patterns for recharging. The uneven distribution of water resources with respect to time and population distribution challenges water supply (UNEP 2002), forcing water managers to decide between damming the water for distribution to people, or resettling people closer to water resources, among other measures.

Ryan James Johnson

Access to Water

Africa's geography and climate, including periodic drought and highly variable rainfall, are not the only—or necessarily the most significant—reasons for the situations of water scarcity that exist on the continent. Growing populations and the associated increased water demand, the costs of providing water and dwindling water supplies compound the problem. Water availability is also restricted by a trend towards urbanization and higher standards of living, poor or no city planning, a lack of resources and competition for available freshwater between sectors such as industry, municipal water and agriculture and even between nations that share watercourses. These have resulted in water stress or water scarcity conditions in the region where the quantity and quality of water may not be enough to adequately provide safe drinking water, food and hygiene, may limit economic development, and can severely constrain environmental resources (Falkenmark and others 1989).

These factors mean that people suffer from a lack of safe drinking water and access to proper sanitation facilities. The Millennium Development Goals (MDGs), described in depth in Chapter 4 (which

Key Facts

Millions of people in Africa suffer water shortages throughout the year

Water scarcity is not simply due to geography: population growth, rapid urbanization, poor planning and poverty are significant factors

Most urban population growth has taken place in peri-urban slum neighbourhoods, overwhelming municipal water services

Sixty-four per cent of people in Africa use improved drinking water sources

Only 38 per cent of Africa's population has access to improved sanitation facilities

Increases in access to improved drinking water sources and sanitation facilities are not keeping pace with population growth

Table 1.3: Definition of improved drinking water sources and sanitation facilities (Source: WHO/UNICEF 2008)

DRINKING WATER SOURCES		SANITATION FACILITIES	
Improved	**Unimproved**	**Improved**	**Unimproved[b]**
Piped water into dwelling,plot or yard	Unprotected dug well	Flush or pour-flush to: - piped sewer system - septic tank - pit latrine	Flush or pour-flush to elsewhere[c]
Public tap/standpipe	Unprotected spring	Ventilated improved pit latrine (VIP)	Pit latrine without slab or open pit
Tubewell/borehole	Small cart with tank/drum	Pit latrine with slab	Bucket
Protected dug well	Tanker truck	Composting toilet	Hanging toilet or hanging latrine
Protected spring	Surface water (river, dam, lake, pond, stream, channel, irrigation channel)		No facilities or bush or field (open defecation)
Rainwater	Bottled water[a]		

a. Bottled water is considered to be improved only when the household uses water from an improved source for cooking and personal hygiene; where this information is not available, bottled water is classified on a case-by-case basis.

b. Shared or public facilities are not considered improved.

c. Excreta are flushed into the street, yard or plot, open sewer, a ditch, a drainage way or other location.

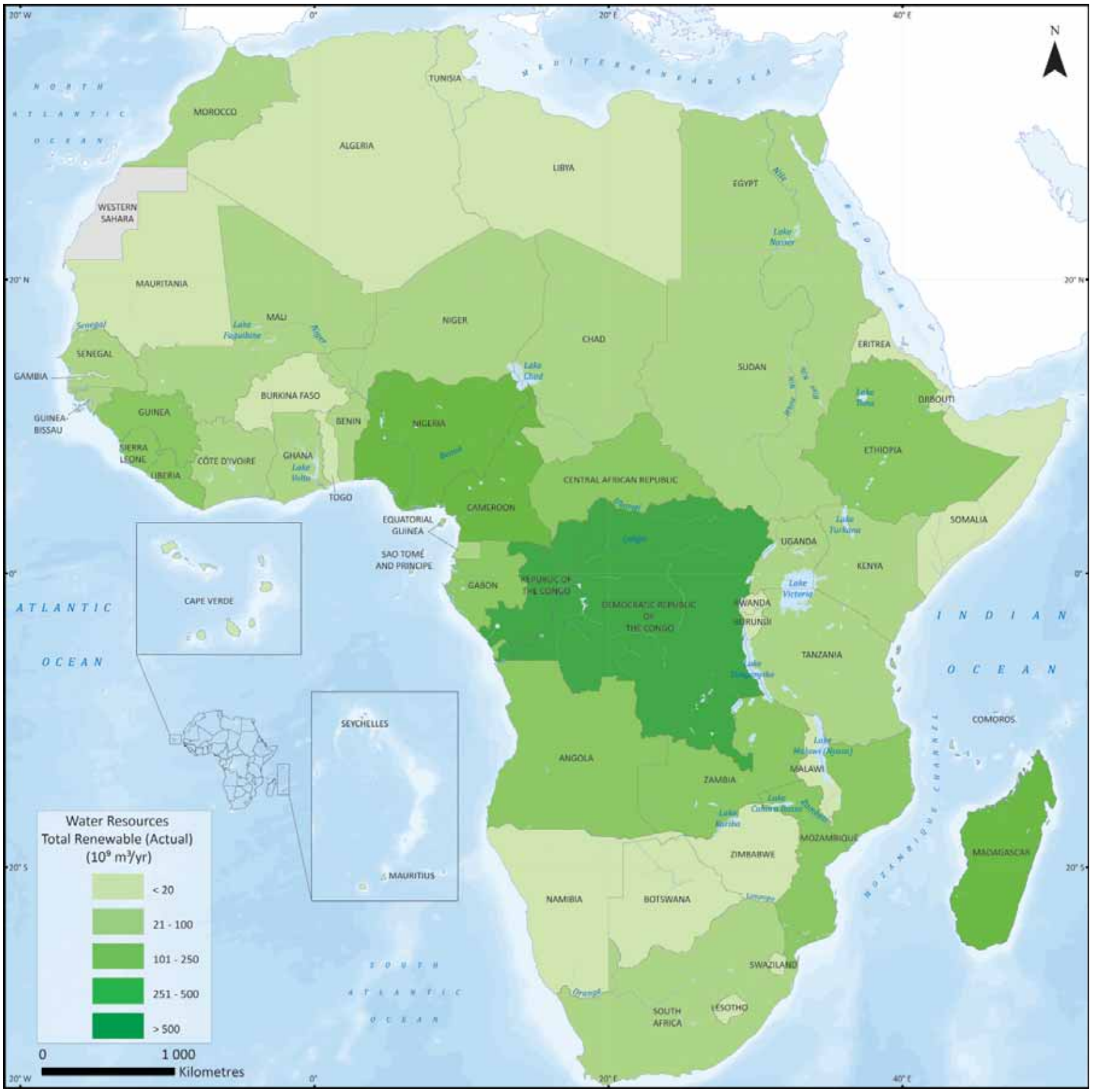


Figure 1.1: Total renewable water resources (Source: FAO 2009)

also provides information by country), set out goals and targets to relieve the most severe poverty in the world and include targets related to the provision of safe drinking water and sanitation facilities.

The water-related target is to halve, by 2015, the proportion of people without sustainable access to safe drinking water and basic sanitation. Data gathered to inform the progress nations are making to meet the MDGs show that in 2006, 341 million people in Africa lacked access to improved drinking water sources (WHO/UNICEF 2008) (See Table 1.3 for the definitions of "improved" drinking water and sanitation). Because of population growth, that number is increasing even though the proportion of people without such access in Africa as a whole decreased from 44 per cent in 1990 to 36 per cent in 2006 (WHO/UNICEF 2008). In other words, increases in coverage are not keeping pace with population growth. Generally, the drinking water situation is worse in rural areas than in urban ones: the average urban drinking water coverage in Africa is 85 per cent while only 51 per cent of people in rural areas have access to improved drinking water (WHO/UNICEF 2008).

Rapid population growth and urbanization, however, have put enormous pressure on municipal water sources. Most of the urban population growth has taken place in peri-urban slum neighbourhoods,

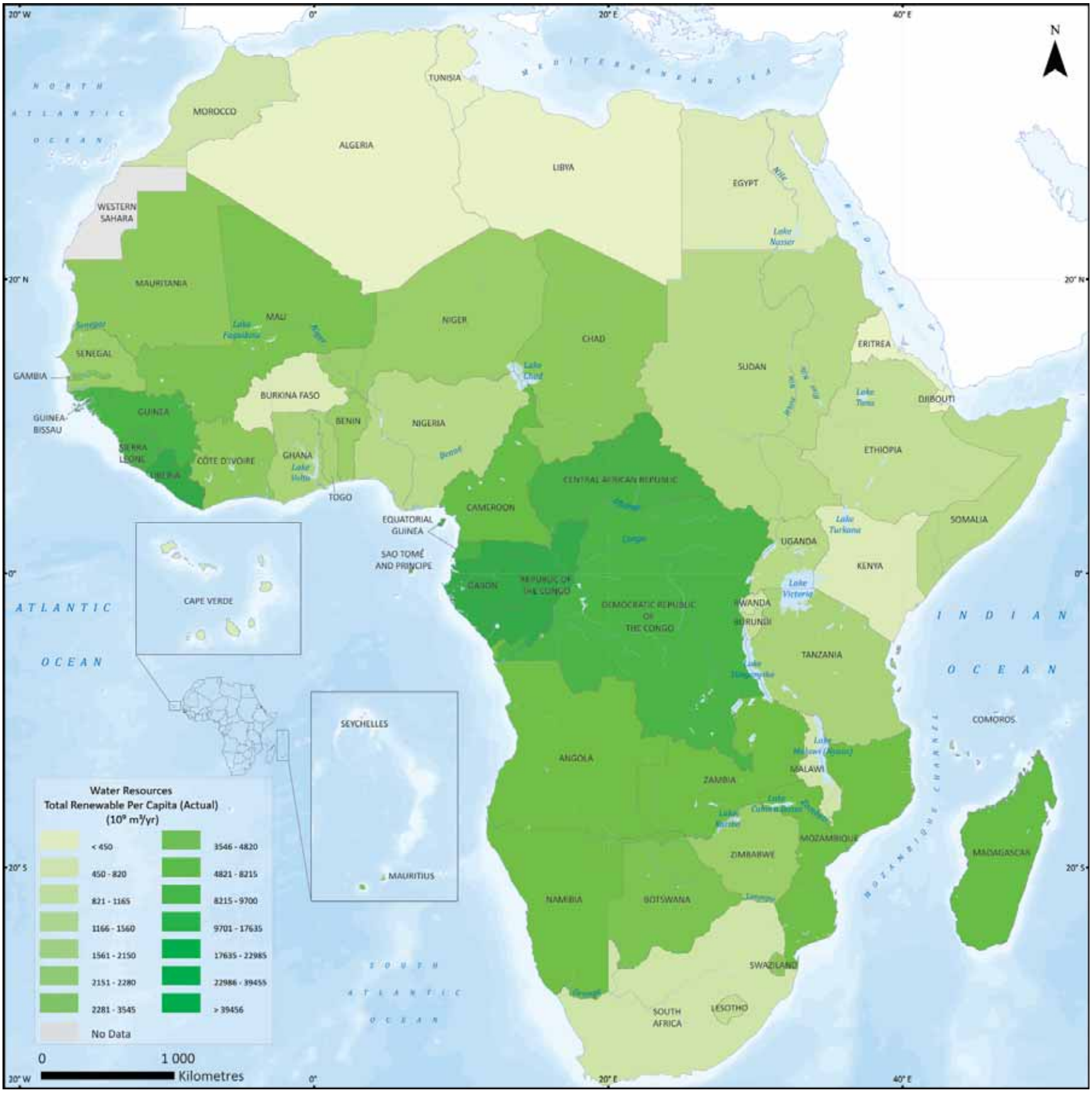


Figure 1.2: Renewable water resources per capita (Source: FAO 2009)

overwhelming the capacity of water supply networks and resulting in an overall decline in piped water coverage in urban areas (Banerjee and others 2008) (Table 1.4).

As for improved sanitation, in 2006 an average of only 38 per cent of Africa's population had access, which represents an increase from 33 per cent in 1990. The African population without access to sanitation increased by 153 million over that time, which shows that the increase in coverage fails to keep pace with population growth. Rural areas are less well served than cities, with urban sanitation coverage in Africa at 53 per cent but only 29 per cent in rural areas (WHO/UNICEF 2010).

Table 1.4: Percentage of urban population accessing various water sources (Source: Banerjee and others 2008)

Years	Piped water	Standposts	Wells/ Boreholes	Surface Water	Vendors
1990 - 1995	50	29	20	6	3
1996 - 2000	43	25	21	5	2
2001 - 2005	39	24	24	7	4

Key Facts

Africa's largest lakes are Lake Victoria, the world's second-largest freshwater lake, and Lake Tanganyika the second-deepest lake in the world

Some of the world's largest dams such as Volta, Kariba and Cahora Bassa are found in Africa

South Africa and Zimbabwe have the most dammed rivers and among the world's countries with large dams ranked 11 and 20 respectively

The Lake Chad basin is the largest endoreic basin (an area with terminal lakes and an interior drainage basin) in the world

Groundwater represents only 15 per cent of Africa's total renewable water resources, but about 75 per cent of its population relies on groundwater as the major drinking water source

Africa's important aquifers such as the Nubian Sandstone, the world's largest fossil water aquifer system, and the Lake Chad sedimentary basin, are losing more water than the rate of recharge

Surface and Groundwater Resources

Rivers

Africa's water is held in large rivers, widespread aquifers, large dams, lakes and wetlands as well as in atmospheric water vapour and soil moisture. The rivers provide transportation arteries, habitat for fish and other freshwater organisms and water for drinking and irrigation.

The Nile River is the world's longest and the Congo and Niger are within the top 25. Africa's rivers have dramatic seasonal variability and inter-annual variation that reflects precipitation patterns in those basins (Walling 1996). For example, the Congo River has a basin area of 3 669 100 km^2, but runoff or discharge at its mouth is 341 mm, which is more than twelve times that of the Nile River, whose comparable basin size covers 3 110 000 km^2 (Table 1.5). This is mainly due to the highly intense rainfall in the Congo's catchment area (Hirji and others 2002, SADC and others 2008). Non-perennial rivers are found mainly in the arid and semi-arid areas such as the Sahara and parts of southern Africa.

Lakes

Africa is also home to some of the world's largest natural lakes (Table 1.6) and human-constructed lakes, or dams. In terms of volume, Africa's natural lakes and dams have a combined capacity that is twenty times that of Latin America's (Wallings 1996). Although it is relatively shallow, Lake Victoria is the

Table 1.5: Characteristics of Africa's four major river systems (Sources: UNEP 2000, Hirji and others 2002)

River	Basin Area (10^3 km^2)	Length (km)	Mean Annual Runoff (10^9m^3)	Unit Runoff (mm)	Interesting Morphological Features
Congo	3 699.1	4 700	1 260	341	Cataracts at Stanley Pool
Nile	3 110	6 850	84	27	Cataracts at Aswan; Drains out of large depression - the Sudd
Niger	2 274	4 100	177	78	Has an inland delta; Entangled in dune fields
Zambezi	1 388.2	2 650	94	68	Falls at Victoria Falls and Caborra Bassa; Linked to the northern Botswana drainage by spillways; Entangled in dune fields

Natural Lakes	Area (km^2)	Maximum depth (m)	Volume (km^3)
Victoria	68 800	84	2 750
Tanganyika	32 000	1 471	17 800
Malawi/Nyasa/ Niassa	30 900	706	7 725
Chad*	18 000	11	72
Turkana	8 660	73	
Albert	5 300	58	

**With low levels 7 000–10 000, with high levels 18 000–25 000 km^2.*

Table 1.6: Africa's largest lakes (Source: Shiklomanov and Rodda 2003)

second-largest freshwater lake in the world, with an area of approximately 68 600 km^2 (Swenson and Wahr 2009). Lake Chad is the shallowest major lake and also the fourth-largest in Africa in terms of surface area; it is also the largest wetland in the Sahel region. The Lake Chad basin, with a surface area of 2 500 000 km^2, is the largest endoreic basin (an area with terminal lakes and an interior drainage basin) in the world (LeCoz and others 2009). In the 1960s, Lake Chad was about 25 000 km^2 in surface area, but it experienced a rapid shrinkage in the early 1970s and has since been fluctuating between 2 000 and 15 000 km^2, depending on the season (Lemoalle 2004). The significant shrinkage experienced since the 1960s is due to a combination of severe droughts and irrigation water abstraction (UNEP and WRC 2008).

Lakes Tanganyika and Malawi/Nyasa/Niassa (Table 1.6) are the world's second- and third-deepest lakes respectively, after Lake Baikal in Russia (SADC and others 2008), with the former holding one per cent of the total volume of freshwater on the earth's surface (Bowen 1982).

Africa's natural lakes have very diverse origins. Those along the East African Rift Valley (Lakes Malawi, Albert, Tanganyika and Turkana) are deep tectonic lakes; some lakes were formed by volcanic action, such as Lake Kivu in Rwanda/Democratic Republic of the Congo. There are also shallow floodplain lakes such as those in the Okavango Swamps. The East African Rift Valley has many soda lakes and there are deflation basins or pans such as those found in the Kalahari and Panlands of South Africa. In addition, Africa also has some high altitude lakes of glacial origin (Walling 1996).

Africa's lakes support important fisheries that sustain millions of livelihoods and contribute to food security. At the continental level, Africa is second only to Asia in the global capture of inland fish; its major inland fishing nations include Uganda, United Republic of Tanzania, Egypt, Kenya and Democratic Republic of the Congo (UNEP 2008).

Africa has 63 shared basins covering about 64 per cent of the continental area (UNEP 2005). Chapter 2 looks at the distinctive features of such transboundary water resources.

Rachel Strohm/Flickr.com

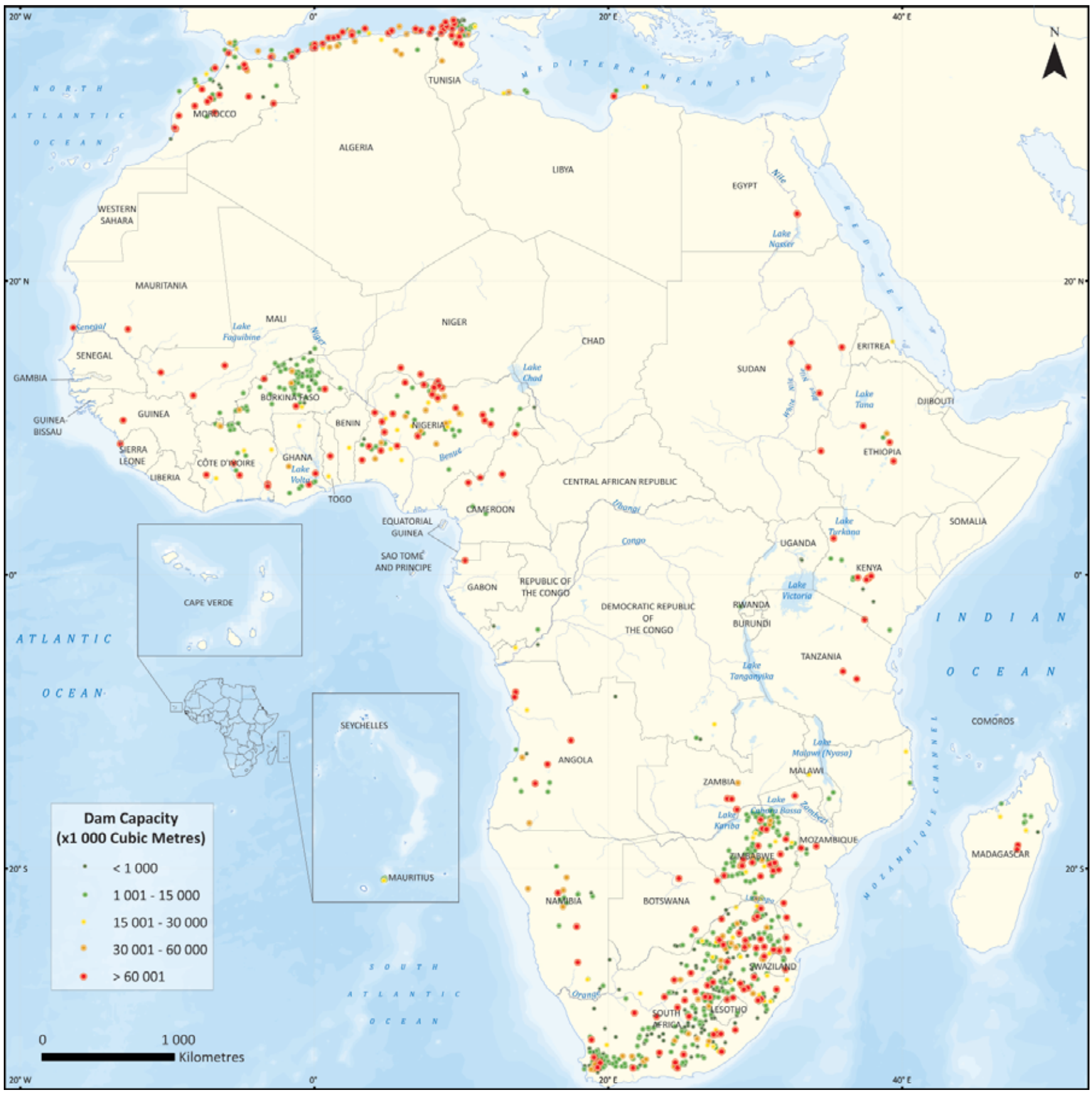
Dams

There is about one dam to every 683 000 persons in Africa, while the equivalent figure for the rest of the world is 168 000 (Strobl, E. and Strobl, R. 2009). More than 1 270 dams have been built on rivers in Africa to store water and supply hydropower and irrigation water (UNEP 2008). Although its large dams are relatively small compared to the continent's natural lakes, a number of African countries have some of the world's largest dams (Figure 1.3, Table 1.7).

Table 1.7: Africa's largest reservoirs (Source: WCD 1999)

Dams/Reservoirs	Area (km²)	Maximum depth (m)	Volume (km³)
Akasombo dam (Lake Volta)	8 480	70	150
Kariba dam (Lake Kariba)	5 250	100	180
Aswan High Dam (Lake Nasser)	5 120	95	162
Cahora Bassa (Lake Cahora Bassa)	2 700	100	52

Figure 1.3: Distribution of dams across Africa



Wetlands

According to the Ramsar Convention on Wetlands (1996), wetlands are areas of marsh, fen, peatland or water, whether natural or artificial, permanent or temporary, with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six metres.

Such areas, which provide many "ecological goods and services", including food sources, wildlife habitat and water storage and filtration, cover about one per cent of the continent's total surface area and are found in virtually all countries.

A wide range of wetland types is found in Africa. Major types include both artificial and anthropogenic lakes, freshwater marshes, river floodplains, swamps and peat lands, in addition to those containing a mixture of salt and freshwater such as estuaries and coastal lagoons. Examples of important wetlands include saline coastal lagoons in West Africa, freshwater lakes scattered throughout the continent, brackish-water lakes in East Africa, the Okavango Delta and Kafue flats in Southern Africa, the marshland along the White Nile in Central Sudan, and the large floodplain wetlands of the savannah region that flow into Lake Chad (Stock 2004, Haller and Merten 2008, Ramberg and Wolski 200, Etile and others 2009). Figure 1.4 shows Africa's main lakes, rivers and wetlands.

Figure 1.4: Surface water showing major natural lakes, rivers and wetlands (Source: UNEP-WCMC 2006)

Estuaries

Estuaries are special types of wetlands found where rivers such as the Congo, Zambezi, Nile, Niger and Senegal discharge into oceans. They normally have a unique combination of physical features associated with their shape, catchment area and connection to the sea and tidal regime (Khedr 1998). This interface between saline waters from the sea and freshwater from rivers is rich in biological diversity. Lake St Lucia in South Africa is an example of an important estuary; it is the largest estuary on the east coast of Africa and is recognized as a wetland of international importance by the Ramsar Convention (Crook and Mann 2002).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Groundwater

Aquifers and groundwater are highly important in Africa, especially for dry countries in the northern and southern sub-regions. Widespread but limited groundwaters represent only 15 per cent of the continent's renewable water resources, but the source of drinking water for three quarters of the continent's population (UNECA and other 2000). The cities of Lusaka, Windhoek, Kampala, Addis Ababa and Cairo are highly dependent on groundwater for municipal water, and groundwater contributes to the supply of other cities such as Lagos, Abidjan, Cape Town and Pretoria (Robins and others 2006).

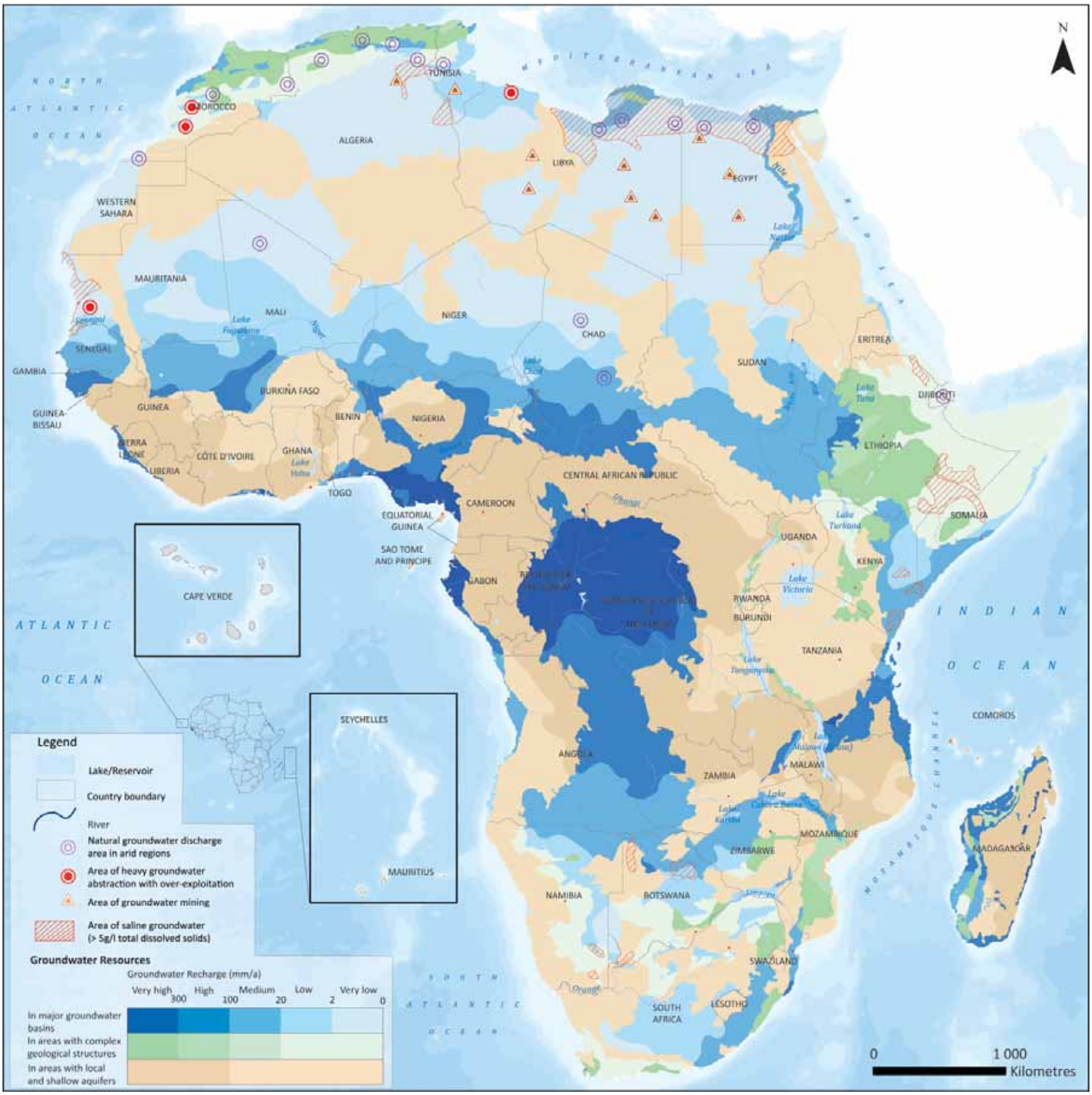
Groundwater plays an important role in providing water for people and animals in rural areas


Tim Parkinson/Flickr.com

of Africa and may be the only practical means of meeting rural community needs in its arid and semi-arid regions (Robins and others 2006). Groundwater is generally cheaper to develop compared to alternatives. Aquifers are usually protected from contamination; however pollution from human activities on the surface is a growing concern. In addition, naturally occurring fluoride [F] and arsenic [As] can cause significant problems. Groundwater is less prone to evaporation than are surface water bodies, so it is a more reliable water source, especially during droughts (Calow and others 2010). Finally, groundwater is a source of seepage into water bodies such as rivers and lakes, and this interaction in the water cycle is important for maintaining the integrity of ecosystems.

Most countries in the desert areas of Africa such as Libya, Egypt, Algeria, Tunisia, Namibia and Botswana receive very little precipitation and therefore rely heavily on groundwater resources. For example, groundwater provides 80 per cent of domestic and livestock demands in Botswana (SADC and others 2008), and is the source of livelihood for 80 per cent of Namibia's rural population needs (Ndengu 2002). In general, groundwater represents the only source of water in North Africa (Braune and Xu 2010). Some of Africa's important aquifers are losing water faster than the rate of recharge, such as those found in large sedimentary basins of Lake Chad, and under the Sahara desert (Stock 2004). Figure 1.5 shows Africa's surface and groundwater features.

Figure 1.5: Surface and groundwater features (Source: BGRM/UNESCO Paris 2008)



Key Facts

Africa's climate is characterized by an overall unreliability of rainfall

There are two rainfall extremes, ranging from near zero in dry regions such as the Sahara Desert, to extremely high rainfall in the Congo-Guinean rainforests

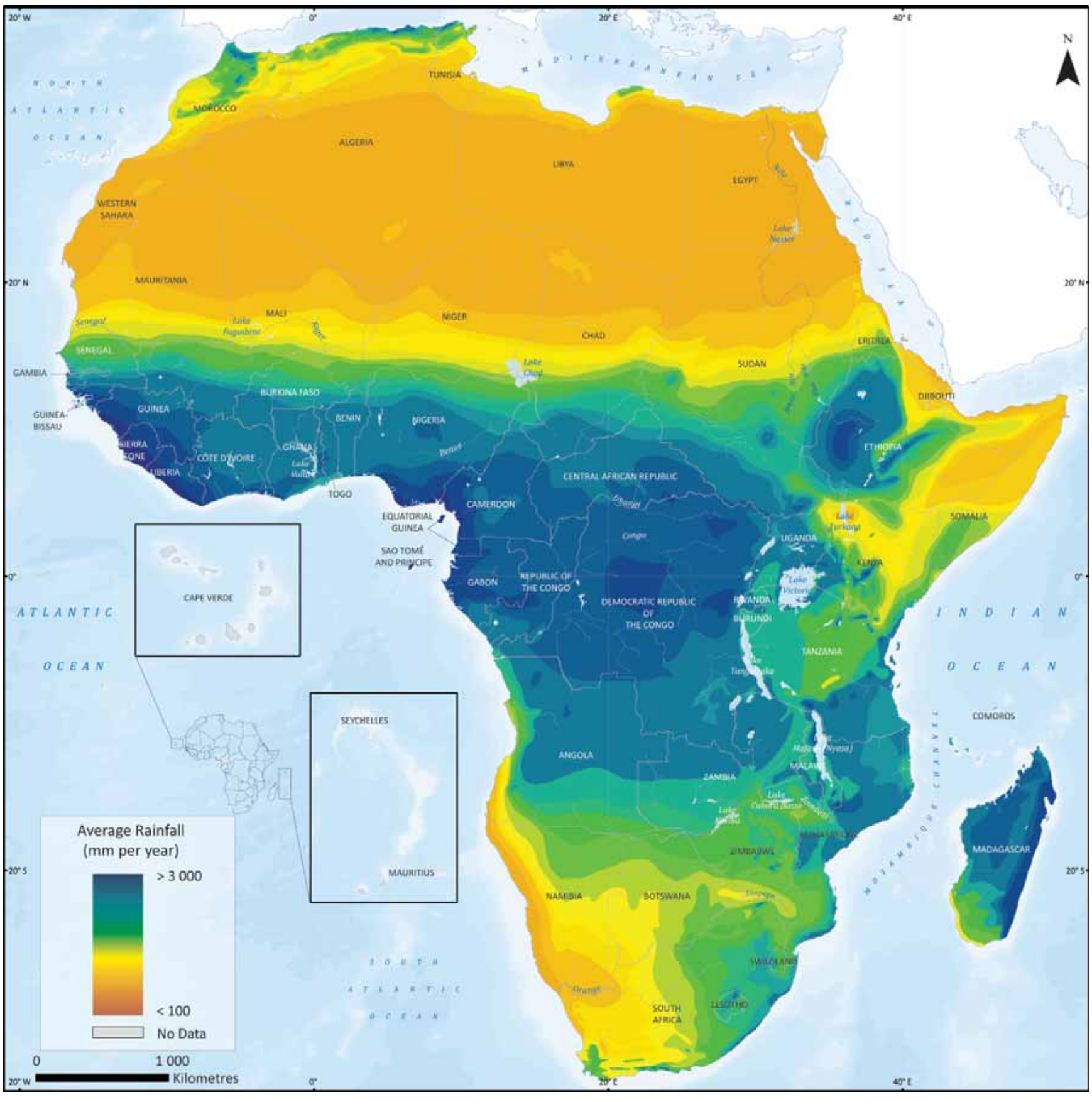
There are pronounced seasonal variations in precipitation in many African regions

Water and the Physical Environment

Climate

The distribution of rainfall varies in space and time, with a consequent overall unreliability of water supplies. In some places there are temporal variations as high as 40 per cent around the mean (UNECA and others 2000). The climate varies from humid equatorial to seasonally arid and tropical and sub-tropical Mediterranean-type climates. The continent's northern and southernmost extremes have temperate Mediterranean climates; in between are the subtropical Sahara and Kalahari deserts. Rainfall varies considerably by season, with some regions, such as the drought-prone areas of the

Figure 1.6: Rainfall map (Period data collected: 2003–2007, UNEP 2004)



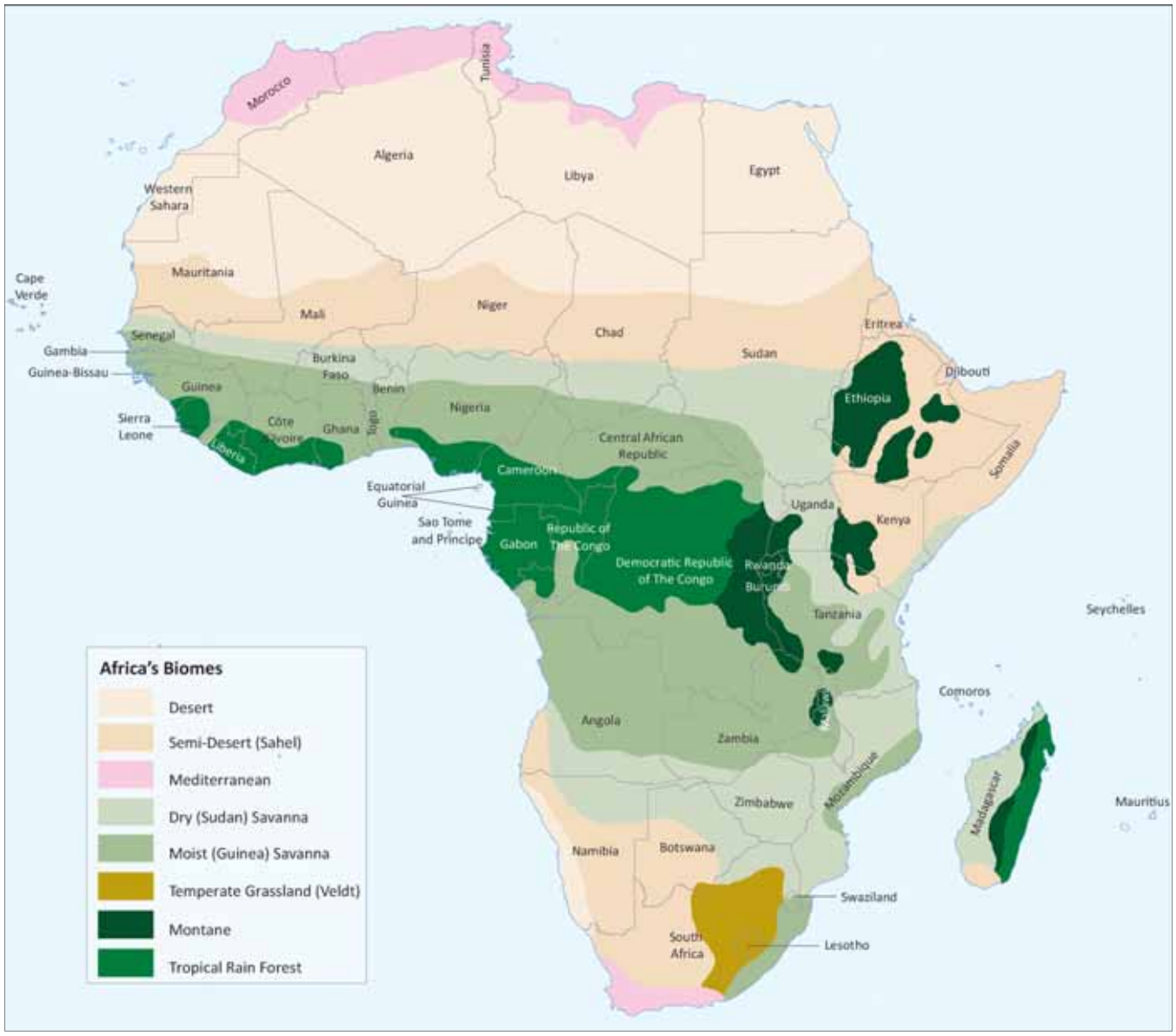


Figure 1.7: Africa's Biomes (Source: Chi-Bonnardel 1973)

Sahel, Southern and Eastern Africa, experiencing pronounced seasonal wet and dry periods (Hulme and others 2001) (Figure 1.6). Topographical features and differences in sea-surface temperatures influence climatic differences between the eastern and western parts of the continent.

The highest rainfall is observed in the Indian Ocean Islands and Central African states, while Northern African states receive the lowest. Overall, annual rainfall reliability is low, and in most sub-regions except Central Africa, it is less than potential evapotranspiration, with a highly variable picture across Indian Ocean Island States (UNEP and WRC 2008). Historical records show that during the 20th century, rainfall has been decreasing over large portions of the Sahel, while rainfall has increased in East Central Africa (Nicholson 2005).

Major influences on the climate come from prevailing wind movements, which are found in the equator region, the two tropics and the two largest deserts: the Sahara in the north, and the Kalahari in the south-western part. Circulation of these air masses brings rainfall to different parts of the continent, and seasonal, inter-annual and long-term circulation dynamics are instrumental to changes in local climate zones (Dinar and others 2008).

Christian Lambrechts/UNEP

Key Facts

Arid lands cover about 60 per cent of Africa

Precipitation, primary productivity and biodiversity are correlated

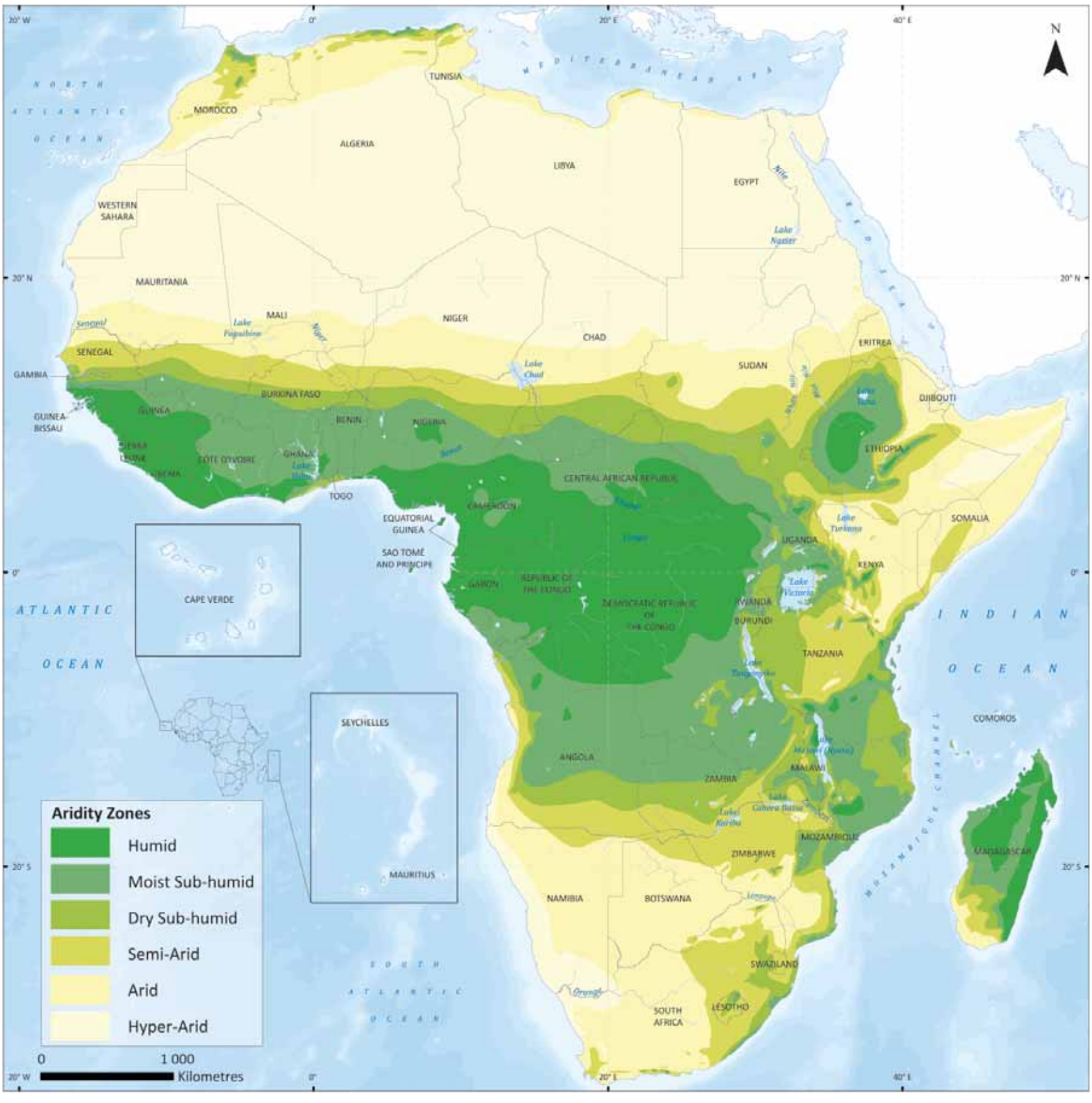
More than 40 per cent of Africa's population lives in arid, semi-arid and dry sub-humid areas

Africa's Biomes

Generally, the pattern of vegetation in Africa largely mirrors its climatic zones, with areas of high rainfall producing the greatest volume of biomass, or primary productivity. On a broad scale, UNEP (2008) has defined the vegetation of Africa in terms of eight major biomes—large areas with similar patterns of vegetation, soils, fauna and climate (Figure 1.7).

Approximately 66 per cent of Africa is classified as arid or semi-arid (Figure 1.8), with extreme variability in rainfall (UNEP 2002). There are three main deserts: the Sahara in the north, and the Kalahari and the Namib deserts in southern Africa. They are situated around the Tropic of Cancer in North Africa and the Tropic of Capricorn in the south. Other arid to semi-arid areas include the belt along

Figure 1.8: Aridity zones (Source: UNEP 2004)



the eastern coast of Africa, and up to the Horn of Africa. More than 40 per cent of Africa's population lives in the arid, semi-arid, and dry sub-humid areas where demand for water and other ecosystems services is on the rise (Ingram and others 2002, De Rouw 2004, Sultan and others 2005).

Droughts during the past three decades and land degradation at the desert margins, particularly the Sahara, have raised concerns about expanding desertification (Herrmann and Hutchinson 2005). The full nature of this problem and the degree to which human activities and climate change are contributing to it are still being determined. However, the negative impact that these degraded lands have on the livelihoods of the people who attempt to utilize them is well documented (UNEP 2008).

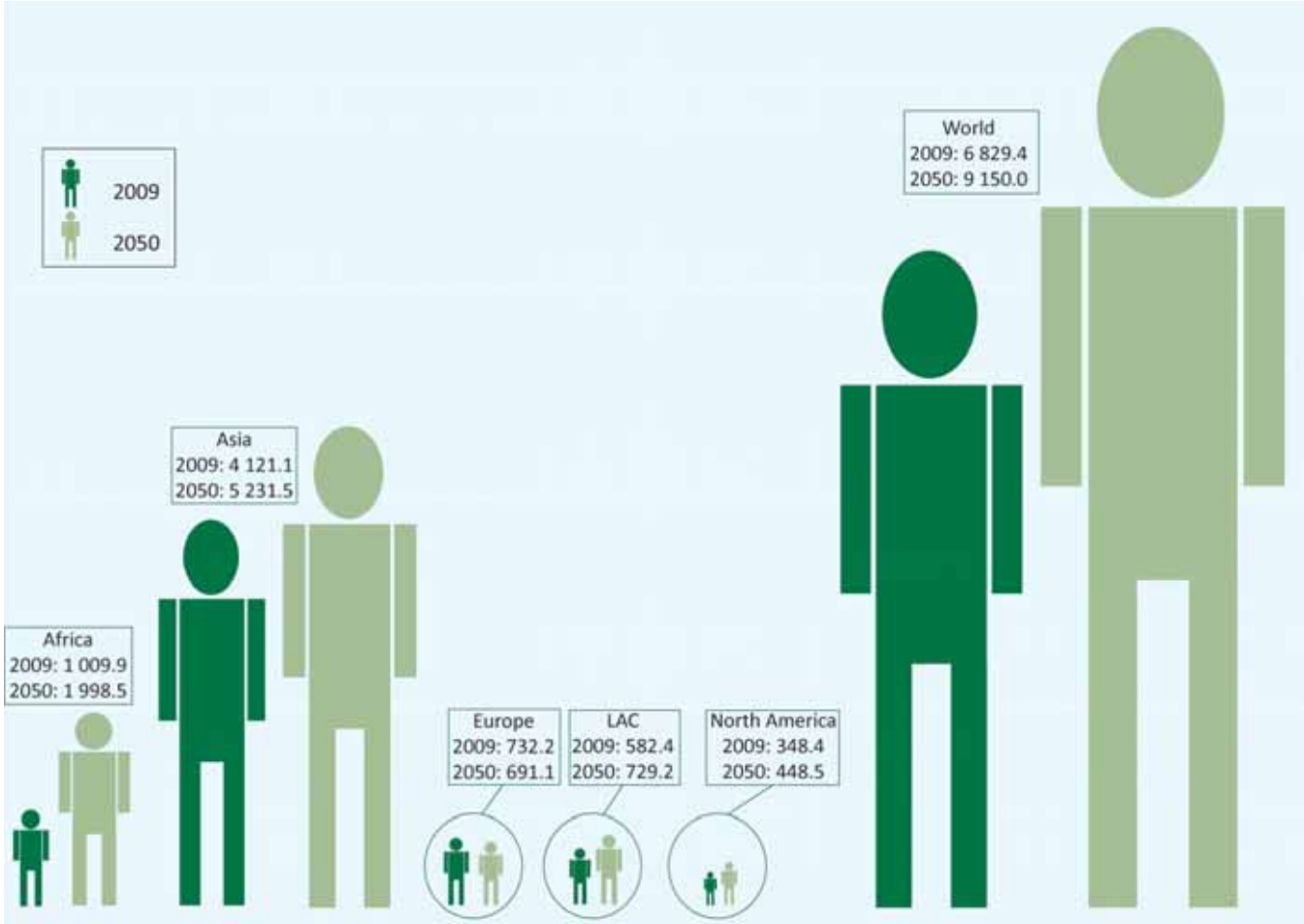


Figure 1.9: Comparative population numbers by world region in 2009 and projected population for the year 2050 (Data Source: UNFPA 2009)

Water and Population

Africa's rising population is one of the main drivers behind the slow progress in water and sanitation provision and in the increasing demand for, and degradation of water resources. Among the world's regions, the continent's average population growth rate of 2.3 per cent for the period 2005 to 2010 was the highest (UNFPA 2009). Africa is the second-most populous continent after Asia (Figure 1.9). Africa also had the highest urban growth rate for the period 2005-2010, although on average it also had the largest proportion of rural population in 2009 (UNFPA 2009). About 40 per cent of Africa's population now lives in cities. Between 2005 and 2010, Africa's urban population grew at a rate of 3.4 per cent, or 1.1 per cent more than the rural population. The urban growth rate over that time was highest in Central, Eastern and Western Africa, although at 58 per cent in 2009, Southern Africa had the highest proportion of urban population (Figure 1.10).

Permanent settlements are sparse in areas such as the Sahara and the western part of Southern Africa, but there are some places, such as the Nile delta, which are densely populated. Unlike biodiversity and primary productivity, which are generally correlated to rainfall availability, the distribution of people in Africa is also influenced by many natural and human induced factors that include availability of land for agricultural activities, the prevalence of natural disasters and disease, conflicts over natural resources, and historical reasons, among others. Nevertheless, people have tended to settle in areas of adequate water, and even the emergence of early civilizations along the Nile River was closely tied to

Key Facts

Africa's population growth rate of 2.3 per cent from 2005 to 2010 was the world's highest

Over that time, Africa's urban population grew at a rate of 3.4 per cent

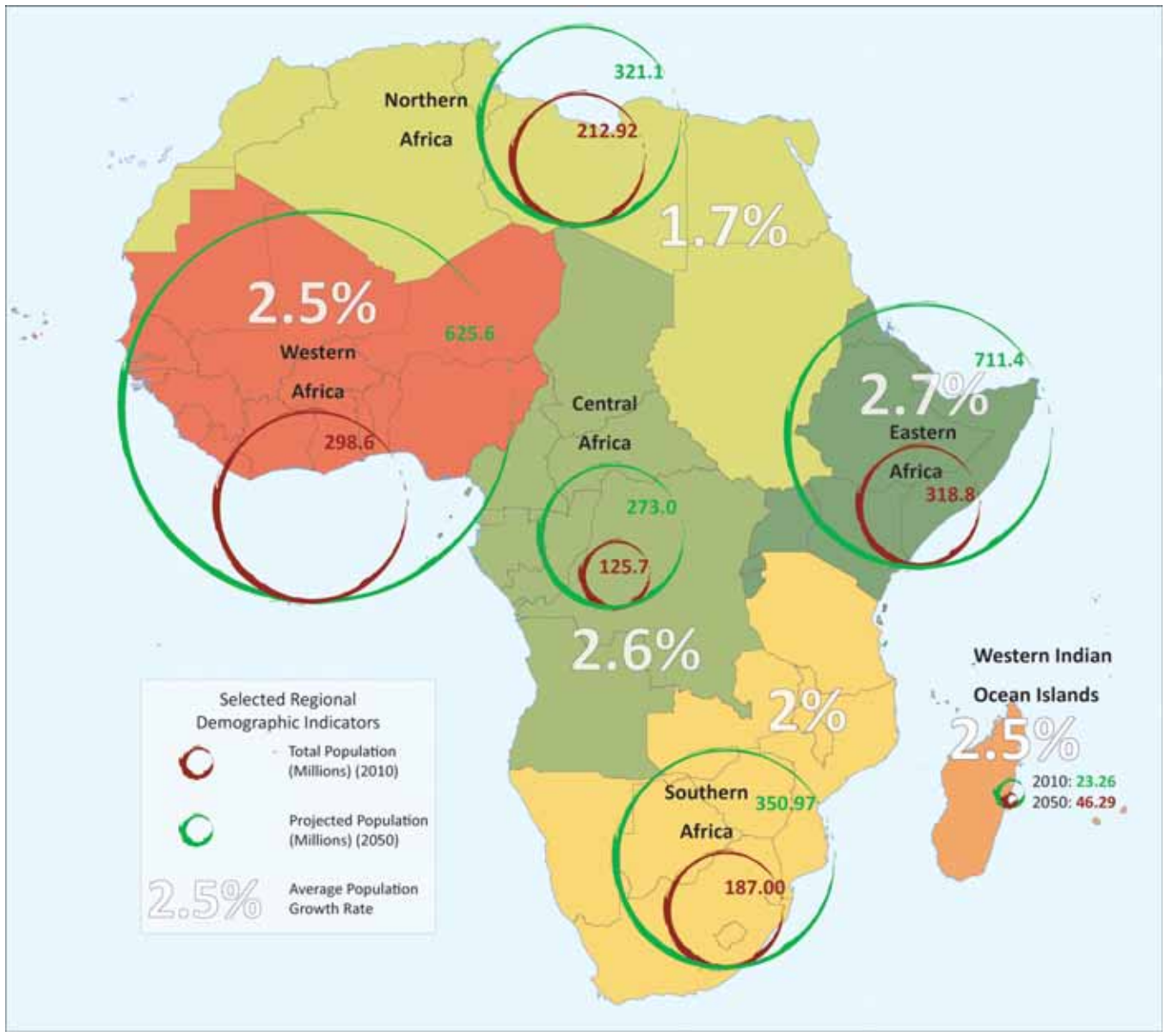


Figure 1.10: Selected demographic indicators for African regions (Data source: UNFPA 2009)

the availability of this critical resource. Countries with high population densities include Nigeria in West Africa, which is also the most populous nation on the continent with more than 150 million people (166 people per km^2) and the Central African nations of Rwanda (394 people per km^2) and Burundi (314 people per km^2) (World Bank 2010). It is estimated that the West Africa sub-region will still be the most populous by the year 2050 (Figure 1.10).

World Bank Group

Water and Poverty

Africa is widely acknowledged as the poorest and least developed continent in the context of the following selected issues:

- Nearly half of the entire population of Africa lives on less than one dollar a day per person (AfDB 2009);
- Malaria remains the leading cause of child mortality and anaemia in pregnant women in Africa, and is endemic in 46 countries (AfDB 2009);
- The prevalence of undernourishment in the total population was 25.5 per cent for the period of 2000-2007 (AfDB 2009), and 30 per cent of Africa's children less than five years of age suffer from moderate to severe malnutrition (Kolo 2009).

Key Facts

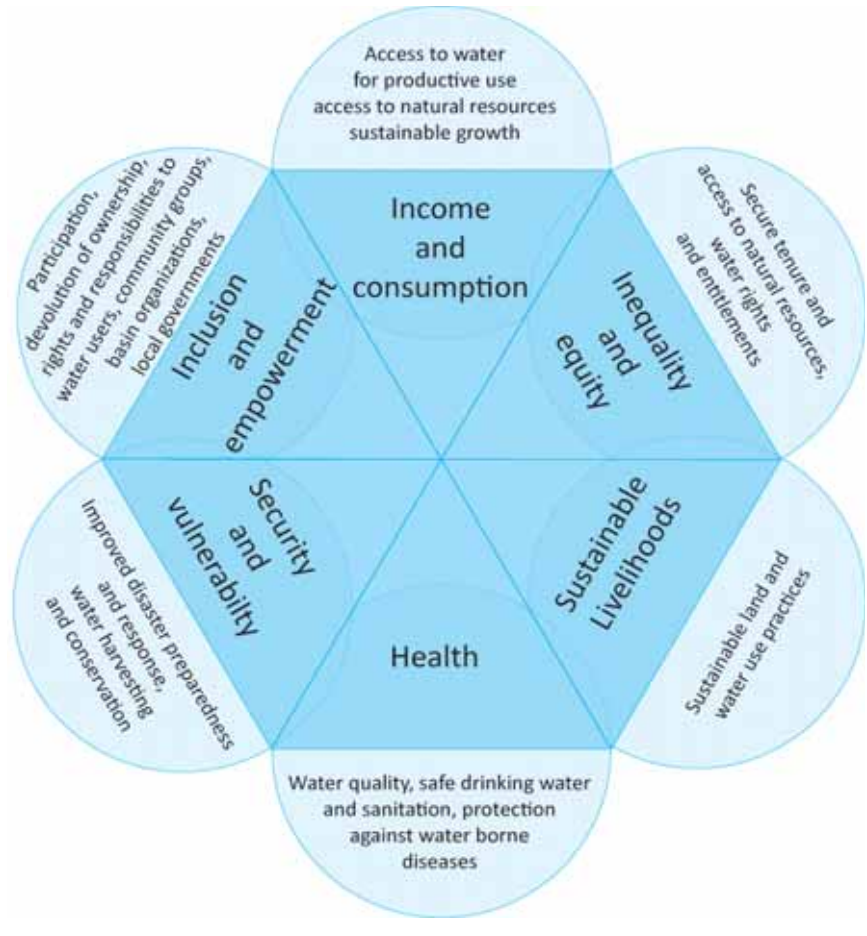
Africa is widely acknowledged as the world's poorest and least developed continent

There are significant linkages between water, the environment and poverty

Many of these issues can be linked to Africa's water-related problems, which are compounded to include food shortages, diseases spread by water and other vectors, and flood damage, among other risks (Van Koppen and Schreiner 2003). Chapter 3 discusses water stress, vulnerability, physical and economic water scarcity and the lack of water for food security in greater depth.

Poverty is a large part of the reason for low levels of access to safe water and sanitation, as well as for lack of other water-related needs such as irrigation. Poverty is widespread in Africa and although it is rapidly urbanizing, the majority of its population is still rural-based and dependent on mostly rain-fed agriculture (as explained in the next section). Poverty is a cross-sectoral issue that is normally defined in different contexts. However, it is widely acknowledged that there are linkages between water, the environment and poverty (Faurès and others 2008, Chowdhury and Ahmed 2010) (Figure 1.11).

Figure 1.11: Linkages between poverty, water, and the environment (Data Source: Hirji and others 2002)



While poverty is a contributing factor in the widespread lack of access to improved water sources, wealth is often linked to the

overconsumption of water resources. For example, a family of eight living in a squatter camp in the Cape Town area of South Africa uses about 120 litres of water a day collected from a tap a few hundred metres away. In contrast, a couple in a nearby rich neighbourhood who have a big garden to water, can use 2 000 litres per day (Pallett 1997). Figure 1.11 shows an example of a framework for summarizing linkages between poverty, water and environment, where the cross-sectoral nature of poverty is shown to cover aspects well beyond income and consumption. The different dimensions of poverty are shown in the triangles, and examples of water and environmental linkages are shown in the semi circles.

Water and Gender

Economically and socially vulnerable groups such as women, the elderly and children often experience considerable negative effects related to the natural environment, such as droughts and floods, and demographic-related factors that include high population densities and land degradation (Saleth and others 2007). The issue most directly related to gender and water is the fact that traditionally, women and young children, especially girls, are instrumental in providing water for their families, particularly in rural Africa. They are thus more adversely affected when there is limited access to water resources. They often fetch and carry water in containers from long distances, spending large amounts of time and energy that could otherwise be used for other productive tasks. Women often perform between 65 and 72 per cent of water collection duties (Black and King 2009, WHO/UNICEF 2008), and some African women spend as much as 40 per cent of their daily nutritional intake travelling to collect water (Chenje 2000) (Figure 1.12).

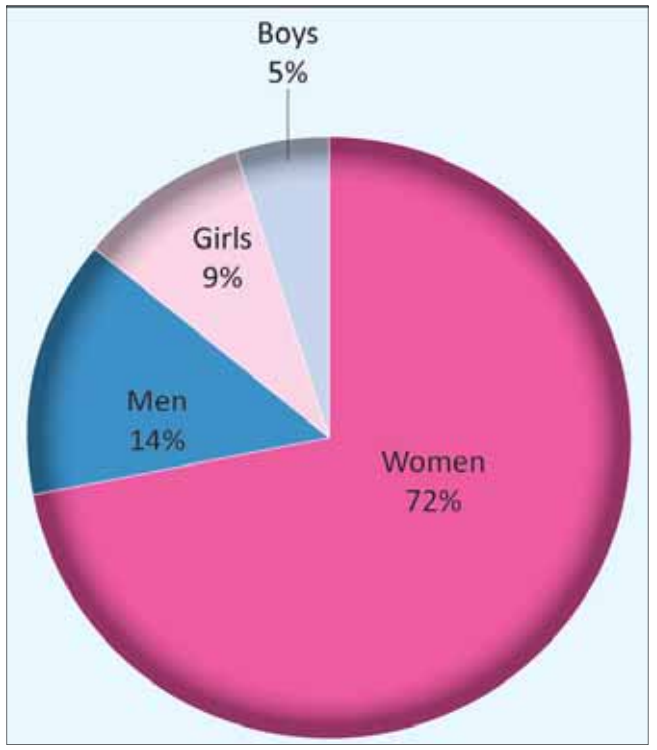


Figure 1.12: Average water collection responsibilities in Africa (Data Source: WHO/UNICEF 2008)

Key Facts

Women and girls are instrumental in providing water for their families

African women often perform between 65 and 72 per cent of water collection duties

Khym54/Flickr.com

Water and Transport

Rivers serve as channels for transportation. The quest for cheaper and efficient methods of transporting goods has seen governments all over Africa increasingly recognize the value of inland waterways in promoting trade between nations, and for the need to integrate different forms of transport networks across the continent (Ford 2007). Examples of the current continental impetus to utilize water transport more include the 20-year rehabilitation and upgrade plan for ports on Lakes Malawi and Tanganyika being carried out by the Tanzania Ports Authority (TPA) to improve the handling of imports and exports of coal, coffee, sugar, tea, timber, tobacco and other commodities through the Tanzanian sea port of Mtwara on the east coast; and the signing of a memorandum of understanding to promote shipping on the Zambezi-Shire water system by the governments of Zambia, Malawi and Mozambique (Mzunzu 2002, Ford 2007).

There are extreme navigation problems on most of Africa's major rivers (Winkley 1995). There is also uncoordinated development between different water use sectors (Toro 1997, Nzewi 2005) and inadequate funding to develop or make improvements to the important river navigation systems. Only a few of the waterways, mainly in the Congo, the Nile and Zambezi basins, are internationally navigable (UNECA 2009). Navigation issues on the Benue River in West Africa illustrate some of the challenges associated with the development of navigation and of Africa's water resources in broader terms.

Case study: Challenges of navigation on the Benue River between Cameroon, Chad and Nigeria

River traffic on the Benue River increased steadily from 1945 and peaked around 1964 with a trade volume of more than 64 000 tonnes of commodities. Major imports included cement, fuel, salt and fertilizer, while cotton fibre, other by-products of cotton and peanuts were the major exports from the Benue River Basin countries. Since 1965, various factors have conspired to reduce river transport to almost nothing. Fuel imports stopped in 1965 and the export of peanuts ceased in 1966. The decline has been attributed to a combination of the following factors:

(1) Irregular natural hydrological regimes. The natural variability of precipitation has meant that navigation has never exceeded a period of sixty days, due to low river flows at certain times.

(2) Environmental pressures. There has been a rapid and uncontrolled increase in the area of cultivation adjacent to the river and insufficient soil conservation practices in the Benue River Basin. This has led to soil erosion and subsequent river siltation, resulting in the stalling of boats in water too shallow to float vessels.

(3) Internal conflicts. Trade was stopped after the 1967 outbreak of the Biafran War and resumed in 1970 but stagnated to around 15 000 to 20 000 tonnes of commodities per year, mainly meeting the needs of cotton companies. In 1980, trade declined again following the outbreak of war in Chad and the impoundment of the Lagdo Dam.

(4) The emergence of other forms of transport. The uncertainty and unreliabilty of river transport saw other forms of transport such as rail and road growing significantly and gaining a substantial portion of the market share. However, the loss of vehicles on roads, problems related to the operation of the railway, and rising cotton production in both Chad and northern Cameroon meant that transport problems persisted.

(5) Human management issues. The long-term management issues of a major link between the Chad Basin and Benue with the Niger Delta is another water transport problem.

(6) Dam construction on the Benue River and its tributaries. In addition to the lowering of water levels due to silting, the overall hydrology of the region has also been affected by the construction of the Lagdo Dam on the Benue, the Shiroro Dam on its tributary in Kaduna and also the Jebba and Kanji dams on the Niger River.

Source: Enoumba 2010

Provisioning services	Regulating service	Cultural services	Supporting Services
Food	Air quality regulation	Spiritual and religious values	Soil Formation
Fiber	Climate regulation	Cultural diversity	Photosynthesis
Fuel	Water regulation	Knowledge systems	Nutrient cycling
Genetic Resources	Erosion regulation	Education values	Water cycling
Biochemicals, natural medicines, pharmaceuticals	Water purification and waste treatment	Recreation and ecotourism	Primary production
Fresh water	Disease regulation	Cultural heritage values	
Ornamental Resources	Pest regulation	Inspiration	
	Pollination	Aesthetic values	
	Natural hazard regulation	Social relations	
		Sense of place	

Table 1.8 Examples of ecosystem services linked to water (Source: MA 2005)

Key Facts

Agriculture—largely rain-fed—is the main source of income for 90 per cent of the rural population

Compared to other sectors, stimulating economic growth through agriculture is four times more effective in raising incomes of poor people; investing in agricultural water has even higher potential multipliers

Figure 1.13: Employment by sector for Africa in 2008 (Data source: ILO 2009, for population: WRI 2009)

Water and Agriculture

Most economies in Africa are closely tied to natural resources. Water is directly or indirectly used in almost every economic sector including agriculture, manufacturing, trade, mining, tourism, transport, and telecommunications, among others.

Agriculture—largely rain-fed—is the single most important driver of economic growth for most African countries (Webersik and Wilcon 2009) (Figure 1.13). The agricultural sector accounts for about 20 per cent of Africa's GDP, 60 per cent of its labour force and 20 per cent of the total merchandise exports, and is the main source of income for 90 per cent of the rural population (UNECA 2007). Compared to other sectors, GDP growth originating in agriculture is about four times more effective in raising incomes of poor people, with even higher potential multipliers from investing in agricultural water (World Bank 2009).

Water is both an ecosystem "good", providing drinking water, irrigation and hydropower, and an ecosystem "service", supplying people, whether they are aware of it or not, with functions such as cycling nutrients and supporting habitat for fish and other aquatic organisms, as well as "cultural services" such as scenic vistas and recreational opportunities.

Table 1.8 provides examples of ecosystem services that have direct or indirect linkages to water, classified under four broad categories defined by the Millennium Ecosystem Assessment, 2005: provisioning, regulating, cultural, and supporting services.

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